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Mineral Matter

— and —

POULTRY KEEPING.

Showing where the old method of Feeding fails; and how to produce

"THE HATCHABLE EGG."

BY

ARTHUR BOSSERT,
Caldecote. Cambridge.

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BY

ARTHUR BOSSERT.

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CHAPTER I.

Is an Egg, an Egg?—We shall see!

Are two eggs alike?

If we show a friend round the farm—a friend who knows nothing of poultry—and afterwards, on showing him a basket of white eggs, pick out a particular one, and yet another, and tell him that the one—showing it to him—was laid by a particular fowl one may have pointed out to him in the pens, and that the other one was laid by some other hen to which one drew his attention, he will laugh, believing it to be a joke. Now, as we know, a good poultryman, one who takes interest in his fowls and is on intimate terms with them, will identify with almost unerring certainty, every egg out of fifty in a basket. A difference between eggs there, then, is!

Well, says the friend, that is just a little difference in the shell; but there the difference ends.

Well,——we shall see!

Tables professing to give the comparative values of foodstuffs invariably contain a serious mistake or, to be more correct, they make a serious omission. They speak of: Proteids, Fat and Carbohydrates; Carbohydrates, Fat and Proteids; Fat, Proteids and Carbohydrates—and all the other variations of the three words, but the fourth one, namely, "Mineral Salts," is usually ignored altogether. Or it is mentioned in a casual way and spoken of as though it were a waste trifle of some

kind thrown into the bargain. Now, unfortunately this fourth component is the most important from the health point of view. The salts contained in all foodstuffs—plant and animal—can certainly not be regarded as food in the sense that they nourish the system, producing flesh and heat, but at the same time the other substances above named —and which are termed the organic substances— would also be of little use did not the salts accompany them; without them the plants and animals would simply be unable to exist. Did the salts not exist the word health would not exist as part of our vocabulary, quite apart from the fact that neither we ourselves nor the vocabulary would have the pleasure of existing were there no salts.

Even the meaning of the word "Salts" is hardly understood by most people. To the ordinary mind it conjures up such compositions as Eno's Fruit Salts, ordinary table salt, or even smelling salts. All these may be very useful in their way, but it is not of these that I purpose speaking.

In their particular way then the salts contained in foodstuffs are equally as important as the other components. They can certainly not replace the others, but neither can the others replace them; and as neither can exist without the other it follows that both—that is the organic substances, Protein, Fat and Carbohydrates, and the inorganic substances, the Mineral Salts—are of equal importance. And in a correctly constituted organism— a plant or an animal—the whole of these substances must exist in their proper proportion; failing that, that organism is not in health. And so, too, it is with the egg!

The salts—here, as there—are not only necessary as lime compounds for the building up of the frame and bone, but they play an important part in the construction of the cells and every part of the body. Without their distribution, in minute particles, through the whole of the system, all plants, animals, and we ourselves should be no

more than a mass of pulp, entirely without vitality, and quite incapable of performing functions of any kind. So, too, the egg! Just as the lime salts in the bones supply the framework of the body, so do the other salts (as well as the lime-salts) distributed in minute particles throughout the whole body, supply the tension necessary to give it form. But that is not their only function, for they, or certain of them, also assist materially in the removal of the waste products formed during the process of combustion of the organic substances—Protein, Fat, Carbohydrates—in the system. And this is of the utmost importance, for unless those waste products can be removed completely and expeditiously disease sets in. Doubtlessly too they act as the weapons by means of which the various microbes, the direct generator of disease, are kept at bay; that is, that, in other words, we should, were it not for the assistance of the mineral salts, be helpless against the attacks of these minute organisms. The magnitude of their importance thus becomes manifest, and we have no right to disregard them owing to their representing only a small portion—by bulk—of the system. Importance cannot always be gauged by bulk—good things are often packed in small parcels. In fact the characteristics of the mineral salts, as they appear in the animal system and plants, are the minuteness of their distribution and their total small measure; and it is possibly mainly this feature that has caused little notice to be taken of them. One occasionally sees them mentioned, but then the remark that they are contained in all foodstuffs in sufficient quantity, is invariably added. Now just this is the greatest mistake, as we shall see; and we shall find that the most important foodstuffs —important from another point of view—are the very ones that contain the least mineral matter. It is this which causes the predicament. Some of them do, possibly, contain a fair quantity, but then it so happens that the salts in evidence are such

as are of lesser importance or not required at all.

For the information of those who do not know it may be well, at this point, to explain that there are a great number of different mineral salts, compounds formed by the affinity between acids and metals. Such salts exist as crystals, and are usually very much like the ordinary table salt in appearance. The chemical definition of a salt is about as follows: A salt is a compound formed when hydrogen in an acid is replaced, either entirely or partly by a metal. And of these salts, as already stated, there are a great many different varieties. The common salt we see on our tables daily—a compound of Sodium and Chlorine—is one of them, but only one of the many. It is also an important one in certain ways, promoting as it does very important processes in the system—the interchange of fluids between tissue cells and the fluids surrounding those cells, for instance. It is also present in considerable bulk, as salt quantities go.

This and various other salts should be acquired in certain proportions with the food. But not only should the plants and animals be well supplied with them, but—and this may be quite new to us—even more so the egg!

The question of mineral salts, as I have just remarked, is usually passed over, reassuringly, with the words that most foodstuffs contain a sufficiency of them. How misleading this assertion is will be seen. And as all vitality depends on these salts we shall see, too, how serious the mistake is.

Actually, it makes all the difference between "Eggs and No eggs" in winter, and all the difference between "No chick and A chick" from the egg that we incubate.

There are then many different salts. Also their functions vary considerably in the system of animals.

There are Lime salts and Sodium salts; Magnesium salts, Iron salts, Potassium salts and many others. Some go to build up the body, others are

mainly required for the performance of different functions. The Sodium salts in particular are employed in this latter way. Of the Sodium salt, known chemically as Sodium-chloride—but which to us is only the common salt—I have already spoken. But other Sodium salts are of quite special importance in that they carry off the waste products formed by the combustion of foodstuffs in the system and without the removal of which life would soon end. Also the Lime salts are of first-rate importance, for they play an important part in the construction of the whole system. They are thus, in a sense, almost of greater importance than the Sodium salts, as without them it would be quite impossible to build up the body at all.

But strictly, of course, we cannot give precedence to any one of them, for their functions are different, and can therefore not be replaced by any other.

It may now be well to explain in what way the Sodium salts, more especially Sodium phosphate, a compound of Sodium and Phosphoric Acid, and Sodium-carbonate bring about the results above referred to. It may be known to some that minute particles of salts of Iron, floating in the blood and acting as barges, so to speak, carry the Oxygen of the air, from the lungs, through the system and deposit it wherever it is needed. Well, the Sodium salts perform just the reverse action to this; they also float in the blood, but instead of carrying Oxygen from the lungs through the system, they collect up the Carbonic-acid-gas, the waste product, conduct it to the lungs, and there cast it off in order that it may be exhaled as we breathe. This same process goes on in the system of all other animals, also in that of our friend the hen and—and that should interest us particularly—also in the egg.

Experiments conducted by Forster and others in connection with fowls and dogs may be of interest here. One would imagine that if one of two sets of similar animals be kept without food entirely,

and another one be well fed with ordinary foods—but lacking mineral salts—those animals that were being fed would have a better opportunity of living than those that were being starved. Such, however, is not the case, but the reverse. And the reason for this simply is that, where food is given without a corresponding accompaniment of salts, poisons are produced by its combustion, and as there is no possibility of ridding the system of them by exhalation, the animal fares even worse than the one that is merely being starved, for it is being poisoned. In the case of the dogs, those fed on the foods robbed of their salts died in from 26 to 35 days, whereas others that were starved lasted from 40 to 60 days.

Another experiment conducted with fowls by a certain doctor of the name of Kionka is even of greater interest here. Kionka fed fowls exclusively on meat and water, the former having been deprived of all its salts. The meat was minced, and two feeds were given daily. For a time the fowls appeared to be in normal health; after a few months, however, signs of disease set in, and these gradually developed into two forms of gout, the one being of an acute nature, the other chronic. In the one case the fowls at first showed difficulty in walking, fell from the perches when jumping down from the same, and drew up their legs as if in pain on placing their feet on the ground. Gradually the weakness increased, the legs were drawn up, the joints swelled and the appetite failed. After the attacks the appetite would improve and the swellings decrease. Soon, however, the attacks would return, and then became more frequent. The feet remained swollen and became useless, the appetite disappeared altogether, and the fowls died rapidly. In these cases the deposits of uric acid in the joints were comparatively small, but in the chronic form, which took a more gradual course, they were very great. The latter form of gout commenced similarly to the other; later on,

however, its characteristics were the development of highly developed Tophi at the joints, and it seems doubtless that both forms of the disease were due to nothing else but the absence of mineral salts in the food, the proportion of the other components of the food having been normal. All such experiments go to show the importance of the mineral salts were their importance not already shown in other ways and did not also the fact that all the more natural foodstuffs contain them, point to their being natural and therefore a natural component of food.

I said natural foodstuffs. I said this almost unintentionally, but it is a very important point of our discussion. I will therefore dwell upon the point a little longer.

We are under the impression that everything that grows in nature is natural. In a sense, of course, it is, inasmuch as it is natural to the moment, that is to say that it is in harmony with the circumstances under which it exists, in other words that it is complementary to its surroundings; but although it is natural in this sense it need not necessarily be natural if regarded absolutely. We have to distinguish very carefully between that which exists independent of the intellect of man and that which is due to interference by the same. The one may, philosophically speaking, be called natural, the other only relatively natural. Vulgarly speaking, one might say that the one, is the other "messed up." Now this "messing up" plays a rather serious role in our affairs so, too, here. It is just this "messing up" that is at the bottom of the whole trouble. We regard a grain of wheat, for instance, as being natural, and are surprised if its naturalness is questioned. At the same time it is by no means natural inasmuch as it is only a distortion of its natural and far smaller relative. So, too, many other grains, plants and, even, animals with which we occupy ourselves. Then, meat, as we consume it, we consider a natural food. Actually, it is

highly unnatural for a reason that may appeal to us when we consider it as a foodstuff for our fowls. The trouble with the meat is this: Quite apart from the fact that it may have been produced artificially, we make it highly unnatural—and unsatisfactory as a foodstuff—by feeding it without the blood. This we throw away, and feed the flesh by itself. Now the flesh contains all those constituents which, during the process of combustion —digestion—form the waste products; and the blood contains all the salts necessary for the carrying off of those waste products. But in our wisdom we have parted the two. And in the case of the wheat and other grains we have a similar result. The enlargement has been all in the one direction, leaving them with an altogether inadequate quantity of mineral salts, and thereby making their consumption quite dangerous unless the deficiency is made up in some other way.

It is therefore not surprising if eggs, laid by fowls that have been fed incorrectly in this respect, hatch out badly, and that the chickens that may actually be produced are handicapped from the start. Acids are produced as combustion proceeds within the egg during incubation, and if, then, sufficient alkaline matter is not present to neutralise those acids—and we must remember that there is no possibility of obtaining salts from elsewhere when once the eggs has been laid—the embryo is overcome by them and destroyed. A great quantity of Carbonic acid gas is developed during incubation and, as will be seen from the first Table I give, a large quantity of Sodium—as well as other salts—is also present in the egg. Were this Sodium not present there would be no possibility of the egg exhaling the gas and the embryo would inevitably die. This is what very often does happen, especially with winter eggs. And one may say that the hatching quality of an egg is directly proportionate to the quantity of salts is contains, as is also the vitality of the chicken when hatched. An egg con-

taining a moderate amount of them produces a chicken of moderate vitality, and an egg well supplied with salts produces the brilliant chick. One may even judge how the fowls that laid the eggs were fed, at testing time, if one has a certain amount of experience in this direction. The embryo contained in eggs produced by hens quite improperly fed die during the first days of incubation; and those contained in eggs from stock that has been fed less incorrectly die later, probably supplying the bulk of the dead-in-shell chickens. In the case of the former a slight red smudge or streak is noticeable at testing time, but these may often be passed over as being unfertile. I have known practically the whole of the embryos of eggs laid by hens fed on a maximum of meat and a minimum of greenstuff die in the shell—and of those that hatched, few only survived. And of such eggs as these the yolks are usually of a sickly greenish yellow colour. Good eggs should have a full-coloured—not necessarily a deep coloured—sparkling yolk. Meat has always been regarded as a good egg producer, and naturally it is, for it is composed chiefly of Protein—as is the egg—but suitable for hatching purposes they are not, nor are they really wholesome as human food. I say they are not suitable for hatching; that is, of course, if we omit to supply the requisite amount of salts in some other way. How unsuitable meat is as a food for producing hatchable eggs is clearly demonstrated by the experiments conducted by Professor Graham, of Guelph College, Ontario, and reported by Mr. Randolps Meech in the "Feathered World" of Dec. 1st, 1911—and again in his own publication "Eggs," in July, 1912. How unsuitable it is is shown by the fact that only 33 per cent. of the eggs laid by hens fed largely on meat, hatched out, and that even in spite of greenstuff, in some form or other, being supplied.

Sodium is thus of the greatest importance in the eggs, and as the analysis—Table I—shows, it is

required in very considerable quantity. Both Sodium and Lime are most important. Actually, of course, as previously remarked, no particular constituent of a harmonious whole can be considered more important than any other if it is not able to replace that constituent; Sodium and Lime can, therefore, strictly speaking, not be regarded as being of greater importance than any other component, their importance only becomes more prominent owing to their special absence in the more artificial foodstuffs and the fact that the so-called richest foods are also the greatest producers of waste products. All important it is that the various salts be present in their correct proportions. Some of them are necessary for one process, some for another; some keep certain organs in health, and others perform some other function. Calcium Phosphate for instance is necessary for the formation of bone and teeth, and is the general agent for promoting the growth and nutrition of the body. Ferric Phosphate (Phosphate of Iron) is required to ward off all inflammatory affections; Postassium Phosphate is necessary for the formation of nerve-substance, likewise Magnesium Phosphate; Sodium Sulphate is contained in the bile and is the chief salt where affections of the liver are concerned. Then, as has already been stated, Sodium Chloride—common salt, made up of Sodium and Chlorine—is chiefly instrumental in effecting the interchange of the fluids in the system. Of Silica the glassy skins of the blades and stalks of grass, and similar plants, consist. If we care to run our eye down the eighth column of the first Table, the column headed by the word Silica, we shall find it particularly in evidence in the case of oats, barley, grass and other plants of the grass type, principally in those of wheat, barley and oats. In the case of the oat and barley—that is the oat and barley seed —it forms the hard husk so well known. The purpose to which the fowl puts it is the building up of the feathers. These consist largely of Silica. To

those who do not already know, it may be of interest to learn that all the harder, glassy stones such as Quartz and Flint are practically pure Silica. So also is ordinary sand, especially the whiter kinds. Glass, of course, being manufactured of sand, is also of the same substance. Feathers, therefore, are no more and no less than flint and suchlike stones built up by the fowl in another form.

All these salts are compounds made up of what is termed a base and an acid. What the word acid means most people know, the base—or alkali, as it is called under certain conditions—is the reverse to the acid and tends to neutralise the same, all salts being either neutral or alkaline but never acid. Into these bases and acids the salts have been split in the table, all the bases of one kind—Sodium for instance—have been collected together and given in one column, and all those of another kind—Magnesium for instance—in another. And similarly has it been done in the case of acids. With this problem of chemistry, however, those who know nothing of the science need not concern themselves, for what the various substances are does not really much matter, important is the quantity in which they are present. They might equally as well be designated by means of numbers as names. And as, indeed, the carrying out of this idea may tend to simplify the matter for those not initiated in the science of chemistry, I will attach numbers to the heads of the columns. Actually column No. 1 represents the Potassium base—Potash; the second, that of Sodium; the third one that familiar substance, Lime; the fourth, one of Magnesium—Magnesia; and the fifth again is one of Iron. The first five columns then represent the bases, and the second four are the acids. Here we have Phosphoric anhydride, Sulphuric anhydride, Silica, and Chlorine. To the first numbers I will add the words Potassium, Sodium, etc.; and for the acids,

Phosphoric acid, Sulphuric acid, and so forth. I am also adding the chemical formulae for the benefit of the chemist.

The exact quantity of each of these items contained in the egg we know, but to determine the quantity required by the fowl for her own use is not so simple. It is true we have the analysis of the flesh of the fowl, also that of the blood and the bones; but we cannot assume that the salts are required exactly in these quantities, for we know that the lime salts, for instance, and which are the chief factor in the construction of bone, remain where they are for a considerable length of time. We also know that others occupy their positions more or less permanently, and that the term of usefulness of others is very short. And some, such as those assisting in the processes of the blood, are doubtlessly used over and over again. The problem is thus somewhat complicated, but before being able to decide as to the exact quantities that should be supplied we shall have to find a solution of the same. How I do this will be seen later on; for the present we will content ourselves with a study of the tables, and as this chapter deals with the first one only we will take that one first.

The Tables have been printed on differently coloured papers so that confusion between them may be avoided, and as the first one has been printed on paper of a blue tint we can speak of it as the Blue Table. As regards this then:

First of all we must consider the following point.

Commonly one hears some foodstuffs spoken of as concentrated foods in contra-distinction to others. The term naturally conveys the idea that such foodstuffs contain a larger proportion of those elements which supply nourishment than others do. In a sense that is correct. The difference between them and the others is, however, mainly this, that they contain a smaller percentage of water or, what amounts to the same thing, a larger proportion of solids. But is this an advantage? In a sense,

again, it is, inasmuch as such foodstuffs are easy to handle; in reality, however, we shall find that it is not. They represent—or principally so—the more artificial foodstuffs and what I said about them will be remembered. But, apart from the fact that such foods are more or less faulty in their composition, we even, unbeknown to ourselves, make another mistake in another direction; we have the idea that by feeding with concentrated foodstuffs we can induce our stock to accept a larger quantity of nourishment than would otherwise be the case. But in this we are greatly mistaken. We quite forget that, whatever the amount of solids eaten, that amount must be accompanied by a certain proportion of water if they are to be rendered assimilable. Experiments with different animals show this very clearly. Of all animals human beings are the most abnormal in this respect, and cannot be taken as a guide. We find the beer-prodigy in Germany consuming 90 per cent. and even considerably more liquid in his rations, and owing, doubtlessly, to the quantities of table-salt consumed in the food 80 to 85 per cent. is considered quite normal in that country. Experiments I myself have conducted show, however, that the normal human being does not differ much from all other animals in the matter of liquid taken in the food. As most people know, various animals such as rabbits and goats, have a particular objection to drinking. With the latter animals I conducted exhaustive experiments in order to obtain information on the point, and I found that by reducing the proportion of natural moisture in the foodstuffs offered them and thereby forcing them to drink, they would allow themselves to be reduced to as far as the 54 per cent. level before actually drinking. Strange to say all the animals experimented with—about 40—commenced drinking at almost exactly the same point. But from this it does not follow that that percentage is the normal percentage for these animals to take, it, of course, only

being their natural objection to drinking that accounts for such a very low figure. If left to choose their food according to their own fancy 72 per cent. is the amount of water consumed. With fowls I have found the figure to be about 75 per cent—from 70 to rather more than 75 per cent. according to the time of year—and, strange to say —or perhaps not strange at all—not only does the flesh of a normally lean fowl contain about that amount of water, but also the egg. We may therefore regard about 75 per cent. not only as the natural proportion for the food, but also as that for both the fowl and the egg. Many people who have not taken special interest in this question may be surprised to hear that about 75 per cent., that is three-quarters, of the food consumed by most animals and human beings is water. That, however, is so.

If we now return to the queston of concentrated foodstuffs we shall find that what we have learnt makes a considerable hole in our erstwhile ideas. If we then imagined that we could force our stock to accept more of the nourishing solids by the assistance of the concentrated foodstuffs we now find that we were mistaken. What we shall find to be the direct result of feeding with concentrated foodstuffs is that the pump will have to be put in action to supply that which the foodstuff lacks. And this brings me to the point we should discuss. Is this plan of feeding a really good one? I think I may emphatically say that it is not. And I think that the reader, before he reaches the end of this book, will be no less emphatic in expressing the view. As we go through the Tables we shall find that the concentrated foodstuffs have one failing in common namely that they are all most deplorably deficient in salts. Most of the salts we require are soluble and suspended in the liquid part of both animals and plants. If we therefore give foods containng little or no water but go to the pump for the latter we shall easily be able to understand what that means and we shall come to the conclusion

that the golden rule to be followed is to endeavour to supply the water by the medium of the foodstuffs themselves and not with the assistance of the cow with the iron tail. Some may point out that not all water is devoid of mineral salts. That is of course so, but unfortunately they are not organised in the same way as they are organised in the plants. In the plants the salts are doubtlessly connected with, or attached to, other substances in some way, whereby they become suitable as food for members of the animal kingdom. When apart from the vegetable kingdom, however—that is in their crude state, and not organised as they are in the plant—they do not appear to be properly acceptable as food. During sickness the matter is different. Here they are accepted in the crude form if reduced to a sufficient degree of fineness, but that question I do not propose going into here. As food for plants, however, they are perfect in the independent state and after having undergone a change in the plant, they become equally excellent as food for animals. We should therefore aim at supplying the water—and therewith the salts—through the vegetable kingdom, selecting the foodstuffs in such a way as to give our hen the opportunity of making up the full complement of water and solids, for herself, and her egg. And this point should never be forgotten.

But I do not propose making a strict calculation of the whole question. We are far too fond of calculating, and although I am giving a great number of figures they are not given with the idea of working out any special and definite rations. I am giving them more with the idea of making my point clear and with the further object that they may act as a guide to the reader. As regards the exact calculation, I propose that that be left to the hen, for in the niceties of that calculaton we shall find her to be far cleverer than we. What I recommend is to adopt the plan I myself have made a point of following, and that is to feed, as much as possible, in the light of what I have said, and then by giving her plenty

of variety, allow her to do her own selecting.

But still further explanations will be necessary before the reader is in a position to make use of the tables.

The analysis of foodstuffs one finds in books, especially those dealing with the salts are often not only complicated, but also misleading. Apart from difficulties due to the chemical terms in which they are expressed, the difference in the proportion of water contained in the foodstuffs makes the comparison very difficult. For instance we have one substance containing say 20 per cent. of water and another 80 per cent., that is to say one containing 80 per. cent of solids, the other only 20. Now in a column containing the entries for a particular component of the first foodstuff we may perhaps find the figure 16 entered and, as the corresponding figure for the second foodstuff 8. We naturally conclude that the first foodstuff contains double the amount of that particular component than the second one does. Actually however that is not so for by the time we have put them on equal terms, by adding the requisite amount of water to the one, the solids in that one have fallen to one-fourth their original amount as compared with the other, and the figure 16 has changed from 16 to 4. Thus to our surprise we find that the relationship of the one to the other is just the reverse to what it at first appeared to be and that the first foodstuff does not contain double as much of that particular component as does the second but that the second foodstuff actually contains double what the first one appeared to contain. I have therefore re-arranged the whole of the analyses in this particular, as also in others, thereby bringing them strictly into line so that they may be compared without more ado. Firstly I am assuming them all to be in the condition in which the fowl will consume them, namely in the ratio of three parts of water to one part of solids, and then as some of the salts exist in very small quantities in the foodstuffs, I have assumed that one ton of each foodstuff is at

disposal and give the salt figures in ounces. In this way very acceptable, and more tangible figures are obtained and fractions are avoided.

The point regarding the 75 per cent. of water and the 25 per cent. of solids may however not be quite clear to all, I will therefore go over that point again.

Some foodstuffs contain as much as 90 per cent. of water, others may only contain 60 per cent. As the fowl cannot do with more than 75 per cent., the superfluous 15 per cent. of the one, will go to make up the deficiency in the other, and the result will be that both are consumed by the hen mixed up with 75 per cent. of water or in the proportion of three parts of water to one part of solids. Thus in both cases we have one part of solids mixed up with three parts of water, and that is the only way in which they can fairly be compared. Of course that amounts to the same thing as comparing the one part of solids of the one foodstuff with the one part of the solids of the other foodstuff, but for the sake of clearness I prefer that we consider the three parts of water as being mixed up with either. We may thus compare the figures just as they stand. I hope that point is clear.

Now, if we look at the Blue Table we shall find that I give an analysis of the egg at the head of it. But it should here again be remarked—so that everything may be clear—that Table I deals with the salts, contained in the various foodstuffs, only. The other constituents, the so-called organic components —and which components make up the bulk of the whole foodstuff—are given in Table II. The salt constituents it will be remembered are present in comparatively small quantities only and for that reason they are given in ounces.

As to the egg then: The total quantity of salts contained in this is, according to our table, 382 ounces, but as the figures here given represent the average obtained from the analysis of a number of hens' eggs of different origin, it

follows that the figure 382—being an average figure only—is not an absolutely fixed quantity and if anything, lower than the highest standard; we shall therefore not be doing wrong by aiming even higher than this figure—should at all events take it as representing the minimum.

What is at once noticeable on looking at the composition of the egg is the large quantity of Phosphoric acid, Sodium and Potassium; and, in a lesser degree, Lime and Chlorine. Iron is repesented by four ounces only, and of Sulphuric acid and Silica only traces exist. The Phosphoric acid is evidently present, partly, as Phosphate of Lime for the formation of bone, but partly too in combination with Potassium, as Potassium Phosphate—to supply the nerve substance with that necessary salt; and partly again for the formation of Sodium Phosphate with the Sodium, Sodium Phosphate being, as already explained the chief agent active in the carrying off of the large quantity of Carbonic acid gas produced in the egg, whilst combustion is going on in the same during the process of incubation. Of the Sodium again a part will be claimed by the Chlorine with which it combines to produce that indispensable assistant in the workshop of the body, Sodium Chloride—common salt—but the greater part of that contained in the egg will go towards the formation of the Sodium Phosphate. Here we see the importance of the Sodium; and the seriousness of the position dawns upon us when we allow our eye to glide down column 2 and observe in what small quantities the Sodium appears in the foodstuffs enumerated. Supposing we were feeding the parent hen chiefly on a mixture of the various cereals and with soft food made up of the brans and meals? And that is quite a common occurrence in winter, especially in the case of the backyard hen of the town. Could we expect eggs? I fear not. To a limited extent a hen will certainly cut her coat according to her cloth and lay an egg of inferior composition. To accomplish this, a good layer will also go to

the extent of robbing her body in order to be able to supply some of the salts required, but she cannot continue this long, for if she did, the same thing would happen to her as happens to good milch stock under similar conditions, she would sicken and die. And the egg actually laid in this way must necessarily be of poor composition. And what could we expect if we attempted to incubate such an egg? Could we expect a chicken to be produced at the end of the three weeks. I fear not. If we tested such eggs on the sixth or seventh day we should probably put them aside as being unfertile or, if we examined them further, we should very likely discover the little red streak denoting that the egg contained a germ, but that that germ is dead. Possibly the germ in such an egg would have died during the first 24 hours. Is it therefore surprising that winter eggs hatch so badly and that so many dead-in-shell chickens are obtained from them? How can we expect anything else with such feeding? In looking down the column—column 2—things certainly look very black and little relief is obtained until we have persevered on as far as Lentil flour. Here we find the figure to be 42. That is a comparatively fine figure and stands head and shoulders out from the other cereals and meals. Lentil flour is a foodstuff that is known but little; but as it is a meal also rich in Albumen (Proteid substance), as we shall see on studying Table II, it should doubtlessly be patronised far more extensively than it is. Especially in combination with Ground Oats for chickens it should be useful. On the road down Table I we shall have come across one or two other foodstuffs not altogether deficient in Sodium; chief amongst these are Sunflower seed—a useful seed—also Tares and Mustard seed. This seed, about which we have heard a good deal of late has the peculiarity that it contains Sodium Sulphate in considerable quantity, Sodium Sulphate being that salt which regulates affections of the liver and which is contained in the white as well as the brown variety of Mustard.

Where fowls are overfed with foods rich in starchy matter and fats, mustard is doubtlessly useful. But beyond these few foodstuffs nothing of much importance is noticeable.

When we get as far as the animal products, however, our hearts are gladdened—but we must not ask the price—at least not of the milk. Exactly how the foodstuffs work out in price will be seen when we get to Table II. The meats are deplorably deficient in Sodium. That fowls, fed largely on meat, cannot be expected to lay eggs that hatch out well is only natural. That it is a good egg producer is however not strange for, as Table II will again show us—but with that we need not yet trouble ourselves—it is very rich in Proteids, that group of organic substances of which the egg is so largely composed. But just the fact that it contains this substance to excess is disastrous for if we understand that not only is carbonic acid gas produced by its combustion but also Sulphuric acid, and which acid in its free state is a most dangerous substance, we can expect no other result than a bad one if no salts are present to remove or neutralise those substances.

Close at hand we shall find the Bloods and if we look at the figures appertaining to these we shall realise what has become of the Sodium of the animal body. A certain quantity of the Sodium contained in Blood is certainly employed in the formation of common salt—in combination with the Chlorine,—but both in Pigs blood as Ox blood, especially in the case of the latter, a considerable quantity of Sodium is left for other purposes. The analysis of Dried blood is somewhere between the two and doubtlessly, consists of various kinds of blood. According to what we here see Blood should be of great service. Knowing this I myself have made extensive use of Blood (fresh blood) in the fowls soft food for a number of years and the results have been quite up to expectations. Harmful effect it has none to the best of my knowledge. In the case of table chickens

it has the effect of making the flesh delicately white and tender and the flavour of the flesh altogether superior, also of keeping the living chickens in a bright and healthy condition. But that is a peculiarity that always results from an abundance of salts and applies equally in the case of the egg and the chicken. Incidentally it may also be remarked that a plenitude of mineral matter helps to produce the active and healthy fowl. Doubtlessly deformed chicks are also prevented thereby.

It is therefore not surprising that both the eggs rich in salts as well as the flesh of the chicken similarly supplied, should appeal more to the palate. That which is healthier naturally does. The flavour is altogether different to that of those devoid of them. And again, being healthier, such eggs naturally hatch better. In winter my own fowls have to rely pretty considerably on Blood for their supply of Sodium and as I have found little or no difference in the hatching qualities of my early eggs and those produced later on in the season, the blood no doubt plays a not altogether unimportant part in the result. As may be imagined I am of course very careful to supply them with the various salts to the fullest extent possible, the whole of the credit can therefore not be given to the blood, nevertheless I am convinced that it contributes to the good results in a large measure. The remark made in connection with Blood practically also applies in the case of Fish Refuse or Fish meal.

We now move on to the Roots. And here the happy hunting ground begins. Mangels, Carrots—Carrots in particular—Turnips, Jerusalem Artichokes, Kohlrabi, Swedes all are well supplied. They certainly have an excess of Potassium, and as this is not desirable owing to a possible action it may have on the stomach and the kidneys it is perhaps a fault. Whether, however, the effect of such quantities as these, contained in the plant, is serious, is questionable; possibly such quantities are

thrown off without much effect and, to judge from practical experience, the disadvantage is only slight in consequence.

Fruits. One will almost be surprised that fruits should be named at all for, to feed fowls on Apples and Pears may at first seem rather ridiculous; I should therefore explain that it is waste fruit to which I am here referring. Some of the finest eggs to hatch are those obtained from fowls kept in orchards, where they are able to obtain as many fallen apples, and such as are partly decayed, as they may please. If one therefore has an orchard and eggs are required for hatching in summmer and autumn one cannot do better than keep those fowls there. But the apples should be ripe, or fairly so.

We now come to the Green Foods and there again we find ourselves in "Salt-land" with plenty to choose from. Here is the sheet anchor to which we must cling in our need. Here it is hardly necessary for me to speak; the reader can see for himself. Especially the leaves of root plants are rich in Sodium; and fortunately, too, some of the leaves that are richest in Sodium, namely Mangel leaves, Spinach leaves, the leaves of the Cos lettuce, Savoy cabbage, Carrot tops and—not to be forgetton—Dandelion, are also fairly normal in other respects. Cabbage lettuce has a considerable excess of Potassium, and to judge by the quantity of Chlorine it contains, a considerable quantity of the Sodium goes towards the formation of common salt. But for summer use these plants are almost too one-sided, for when hens that are at liberty have better balanced greenstuff—and nothing can well be better than grass—they will refuse them. For balancing up winter diets however they are invaluable. Some of the summer plants, such as Clovers, contain comparatively little Sodium, but are very rich in lime instead.

But one thing we must regret, and that is that so many of the leaves and plants enumerated are unobtainable, or practically so, during winter months

—just when we want them. If we work steadily through the list we become unpleasantly conscious of their vanishing, one by one, from our grasp—that is as winter foodstuffs. Quite unpleasantly so, in fact. Grass is to be had to a certain extent for the fowls at liberty, but there is not much to gather in with the lawn mower for the fowls kept in towns and under the intensive system, the system of keeping fowls in confinement which originated in America and is being promoted with so much energy by our friend Mr. Randolph Meech, of Poole, Dorset. And the mention of the intensive system reminds me of the last item on the list of green foods, sprouted wheat, oats, and barley. These analysis are taken from seeds sprouted on soil. Oats sprouted in boxes —for it is oats that are recommended for sprouting in this way—have one great drawback, that being that, under ordinary circumstances, they contain no more mineral matter than the oats from which they are produced. And that as we know is very little. That is unfortunate for as we have got the plants as it is, we might as well have the salts along with them, and the question naturally arises whether that desideratum cannot be obtained in any way. I have never had any doubts on this point and have, from the first—that is since I first heard sprouted oats mentioned by Mr. Meech in connection with the intensive system—treated my sprouted grain in such a way as to give the plants an opportunity of acquiring the necessary salts. Plants cannot absorb salts unless these are in sufficiently fine particles; the crude salt must be reduced to, from a thousandth to a millionth of its original bulk, that is to say it must be reduced and evenly mixed with some other substance a thousand to a million times its size. This can be accomplished by trituration or, in the case of the salts soluble in water—and most of them are soluble in water—they need only be dissolved in a quantity of water equal to a thousand to a million times their own bulk. I therefore made a point of watering the grain with water in which certain salts,

in certain proportions had been dissolved. Proof I certainly had none that the salts were being absorbed, but now, on studying through Wolff's "Aschenanalysen" in connection with the book I am just writing, I come across experiments dealing with this subject. Not only with oats, wheat and barley were the experiments made, but also with Buckwheat and Rye. And from these it is quite clear that the plants may successfully be fed in this way. The method even has another little special advantage for, as plants will, to a considerable extent, absorb according to the food offered, they may be fed in a more or less one-sided way to suit our requirements. As Sodium Phosphate and Calcium Phosphate are doubtlessly the two salts it is most difficult to obtain in plant food, I have made a point of feeding with these chiefly, and as many salts interfere with each other in solution it may be best if those who wish to follow my plan employ these alone, and separately; employing the one salt in connection with one kind of plant and the other in connection with another. Wheat, Rye, Oats and Barley are Sodium plants, it will therefore be best to make use of the Sodium Phosphate in connection with these and select Lime plants to act as a medium for the Calcium Phosphate. In this way excellent green food may be produced for fowls in winter. As lime plants Mustard, Hemp seed and Rape seed take first place. The layer should not be too thick. Of Mustard the white variety is the cheaper and, I believe, the better for the purpose. I have the Sodium plants placed in one set of boxes and the Lime plants in another, and have the former watered with the Sodium solution, and the latter with the other. The salts in themselves are very inexpensive, and as only very small quantities are required, the cost of this improvement is almost nothing. Of the salts one part should be dissolved in about 1000 parts of water, an ounce thus sufficing for about six gallons. It is best to dissolve say one tenth of an ounce in half a pint, or so, of water and then add a little of this solution to

the water that is to be used for watering the plants. If much watering is to be done a larger quantity can of course be dissolved at one time. In practice I do not think there is any need to trouble about any but the two salts named, especially if water, other than rainwater, is used. Rainwater is, of course, practically devoid of mineral salts whereas well-water and surface-water contains different salts in greater or less proportion. The sodium and lime salts may be obtained from any chemist, but Messrs. Bruckner, Poultry Food Specialists, of Toft, Cambs., who are also supplying some of the foodstuffs I specially recommend, are now offering parcels of such salts for sale. But here I must again point out that it would be of little use to give the salts to the fowls direct. Some salts can doubtlessly be assimulated in the crude form, notably the common salt and some forms of lime, but then these can probably only be made use of for certain processes unless organised by the plant. .The fact, for instance, of a hen being able to form the shell of her egg from crude lime does not necessarily prove that she can also make use of it in building up her body. The addition of small quantities of Phosphate of Lime and Carbonate of Lime to the soft food can however be recommended, say 1 oz. of each for every hundred fowls per day.

But to the whole process still another little improvement may be added. It is desirable that the roots have plenty of opportunity of absorbing the salts; I have therefore adopted the plan of bedding the grain on a thin layer of sand placed in the bottom of the sprouting box. Into this the roots soon make their way and are able to feed on the considerably larger amount of water held captive by the sand, also on the small quantities of soil invariably mixed up with the sand and which contains not only mineral matter, but also other nourishment for the plants. And then at the fiinsh these, sand and all, may be given to the fowls, the sand even coming in useful as grit.

Another remark that may not be out of place here is this, that it is important to supply all plants well with any salts that may happen to be wanting in the soil in which they grow and that it is rarely out of place to dress grass land with any one of the lime manures sold for the purpose. This is money judiciously spent and shows up in the quality of the stock. There is no doubt at all that the fuller—so to speak—we get our stock with the various salts, the more active and vigorous they are and the less prone they are to disease. Prevention is better than cure; and of that one becomes pleasantly conscious when feeding on the lines I propose.

Having searched for Sodium we should now look through our list in search of Lime, the other substance which is conspicious by its absence in the cereals and meals. But this, in the main, I will leave the reader to do. I will only draw attention to some of them, partly because they are lime foods and partly, for general reasons. Milk, for instance, is an ideal foodstuff in most respects, and that will be one of the first to arrest our attention. Here the proportions of the various salt-components are particularly favourable. Potassium, of which excess is undesirable, is moderate; Sodium and Lime are good, the latter especially; Phosphoric acid is almost exactly as we require it; Sulphuric acid is practically absent—that doubtlessly because this food of young animals contains no Carbohydrates in connection with which it would be necessary. Silica, too, is also practically absent, and Chlorine, Magnesia and Iron are not far wrong. Milk may therefore be regarded as being a first-class foodstuff in the matter of mineral salts; but it may come as a surprise that that much despised younger sister of this gracious lady, Skim Milk by name, should even excel her in quality. Greater still, however, will be the surprise on discovering that sister number three, Skimmed-by-Machine, is more worthy still of our admiration. Ladies do not always prove to be just as expected,

and so it is here; and fortunately too—as in the case of the ladies—the surprise lies in the pleasant direction. Why the surprise, as regards the milk, should lie in the pleasant direction is not at once clear for, that skimmed milk should in any way be superior to the milk as it comes from the cow is difficult to belive, and therefore requires a little explanation. As I think I have stated before, the salts are mainly dissolved in the fluids of the animal body and in the sap of the plants. In the milk too nearly the whole of the salts are suspended in the watery parts. To the fat none are attached and as it is this which is removed from the milk by skimming it is evident that none are removed with the fat and that after the fat has been removed, that which remains is proportionately richer in salts. It has often been wondered at that children can be reared on skim milk at all, the impression being that it is quite valueless. What we have just seen goes to explain the matter in a large measure, and when we come to compare the organic substances as given in Table II we shall find that in that department too the skim milk is not so very inferior. Yet, the absence of the fat is of course a serious matter where infants are concerned, for these are not able properly to assimilate carbohydrates in place of the fat as older persons would do. For our purpose, however, skim milk is infinitely more valuable at a penny, than new milk at threepence or more, for young chickens are able to digest carbohydrates.

Another substance I should draw attention to is Green Bone. This is a most one-sided foodstuff, being practically all Phosphate of Lime together with Proteid substances and Fat, with practically nothing in the way of other salts. All one-sided foods must be used cautiously, and so Green Bone. Here we have a great excess of Phosphate of Lime and nothing whatever to neutralise the waste products resulting from the combustion of the Proteids and Fat. The presence of the two last-named substances show it to be a good egg producer, but given

in larger quantities it can neither be good for the hen nor can hatchable eggs be expected to result from it. Where it comes in very useful is when used in small quantities to balance a food up with Lime. A very great quantity of such green food as Spinach would be necessary to put the balance right if large quantities are used.

What we always have to study is, not the quantity of any one substance that may be considered nourishing or valuable in some other way—but the general balance of the whole food. One thing in excess of the others is never desirable especially not if hatchable eggs are required. A one-sided diet will also always be more costly than a properly balanced one for the reason that in a one-sided one certain constituents cannot be assimilated or made proper use of owing to other complimentary components being absent. I can therefore not emphasize the importance of a well-balanced diet too much. The more perfect the proportions in the diet the better will the eggs hatch and the stronger will the chickens be. It is just in this direction of one-sidedness that the mistake has always been made. The Proteids, that is that group of organic substances which is made up chiefly of Albumen, Casein and Fibrine, have always been considered so very important—and doubtlessly they are important in their proper measure—and the result is that they are often fed to excess without considering that, to commence with, they are the most costly of the food constituents and that the Sulphuric acid produced during combustion from the Sulphur they contain must, owing to its great voracity and destructiveness when existing in the free state, do a deal of harm by attacking the tissues of the system. Fed in the proper proportion however and with the proper compliment of mineral salts it does its full work without doing harm.

I find I have unwittingly moved on to the discussion of the organic constituents of foodstuffs, and as that subject is not connected with Table I, but Table II, I will pass on to that table.

TABLE I.

TABLE I.

An analysis of the Mineral Salts of various Foodstuffs, the quantities given being the number of ounces contained in one ton of Food made up of one part of Solids to three parts of Water.

Name of Foodstuff.	Total Salts. T.	Potassium. K_2O. 1	Sodium. Na_2O. 2	Lime. CaO. 3	Magnesium. MgO. 4	Iron. Fe_2O_3. 5	Phosphoric acid. P_2O_5. 6	Sulphuric acid. SO_3. 7	Silica. SiO_2. 8	Chlorine. Cl. 9
Fowl's Egg (contents)	382	67	88	42	4	1	144	1	1	34
Flesh of Fowl	276	84	51	9	11	0	99	0	0	22
Blood of Fowl	401	70	114	4	1	.15	101	4	0	92
GRAIN.										
Wheat (large	188	59	4	6	23	2	88	1	4	1
Wheat (small)	209	66	5	7	25	2	98	1	4	1
Rye	192	61	3	6	22	2	91	3	3	1
Barley	280	46	11	2	35	5	92	8	80	1
Oats	310	55	6	11	23	4	81	5	122	3
Maize	156	46	2	4	24	1	72	1	4	2
Rice	104	26	4	3	12	1	55	0	3	0
Dari	178	34	5	2	35	5	84	0	13	0
Peas	272	117	3	14	22	2	98	9	3	4
Buckwheat	131	30	8	6	18	2	62	2	1	2

	T.	1	2	3	4	5	6	7	8	9
Tares	273	82	22	23	24	2	100	10	3	7
Millet	307	34	4	2	29	4	68	1	164	1
Linseed	334	101	7	26	47	3	138	8	4	0
Hemp seed	472	94	5	111	27	4	170	1	56	4
Rape seed	400	98	6	58	47	5	170	9	6	1
Sunflower seed	359	58	26	27	44	6	129	8	52	9
Maw seed (Poppy)	550	74	6	192	52	2	171	10	18	25
Mustard seed	376	61	20	72	38	3	151	19	10	2
Clover seed (red)	404	142	4	27	52	6	154	9	5	5
Clover seed (white)	357	130	2	26	41	7	121	17	8	5
MEALS.										
Barley meal*	280	46	11	2	35	5	92	8	80	1
Pea meal*	272	117	3	14	22	2	98	9	3	4
Bean meal*	345	143	4	17	25	1	133	13	3	6
Wheat meal*	188	59	4	6	23	2	88	1	4	1
Wheat meal**	209	66	5	7	25	2	98	1	4	1
Maize meal*	156	46	2	4	24	1	72	1	4	2
Rice meal	545	62	14	14	97	3	240	2	112	1
Soya bean meal*	284	125	3	17	25	2	103	8	0	1

* The salts have been taken as being identical with those of the whole seed. The compositon of these meals depends on the amount of flour sifted out during the process of grinding. Generally speaking the proportion of salts is greater in the meals than in the whole grain owing to the fact that part of the flour has been sifted out and the bran and husk contains more mineral matter than does the flour.

** Prepare from small wheat.

	T.	1	2	3	4	5	6	7	8	9
Linseed-cake meal.....	525	128	8	45	83	6	167	17	67	4
Decort, cotton-cake meal...	660	156	0	29	100	10	303	8	54	0
Groundnut-cake meal	324	100	9	16	52	1	116	9	12	9
Oatmeal or Groats.....	280	59	6	9	29	3	116	1	56	1
Sussex ground oats	303	53	7	9	26	4	84	6	111	3
Linseed meal*	334	101	7	26	47	3	138	8	4	0
Lentil flour	311	108	42	20	8	6	113	0	0	14
Bran	490	137	3	15	79	3	243	4	2	4
Middlings (Pollards)	419	115	3	13	65	3	208	5	2	5
Brewers' grains	406	15	4	57	43	2	150	0	135	0
Malt sprouts	657	210	12	19	19	10	173	26	142	46
Biscuit meal†	283	76	2	12	42	4	139	3	2	3
ANIMAL PRODUCTS.										
Cow's milk	531	127	32	122	14	10	147	7	1	71
Skimmed milk	696	185	47	147	14	14	195	11	2	81
Machine-skimmed milk ...	731	194	49	154	15	15	205	12	2	85
Meat (average of various animals)	39	14	4	1	1	0	16	1	0	2
Fish refuse	530	96	144	28	15	1	131	7	0	108
Fish meal.....	1096	72	108	420	12	8	390	5	0	81
Granulated meat	157	9	5	37	6	22	72	2	1	3
Ox blood	337	24	141	4	2	29	17	10	3	108
Pig blood	386	85	107	5	5	32	44	4	1	103
Blood (average)	361	54	124	4	3	30	31	7	2	106

† The composition of Biscuit meal varies considerably.

	T.	1	2	3	4	5	6	7	8	9
Dried blood	352	39	134	4	3	31	26	7	1	108
Green bone	2762	4	1	1360	27	41	1268	1	0	60
ROOTS.										
Mangel	700	370	108	29	32	6	59	22	16	58
Swede	636	299	36	72	23	4	92	61	7	42
Kohlrabi	736	262	43	81	45	22	162	65	19	37
Turnip	896	405	88	95	33	7	113	97	17	41
Carrot	621	226	130	70	27	6	79	40	15	28
Potatoes	384	208	10	9	17	4	59	23	42	12
Jerusalem Artichokes	536	248	69	17	15	19	72	25	51	20
Onions	452	154	11	104	21	10	78	25	38	11
FRUIT (Waste).										
Apples	287	105	71	11	25	4	40	18	13	0
Pears	163	89	14	13	8	2	25	9	3	0
Gooseberries	265	104	23	33	15	12	53	16	7	2
Plums	391	236	2	33	22	13	61	15	9	0
GREEN FOODS.										
Meadow grass (young)	764	239	32	72	54	13	63	41	208	42
Meadow grass (best pasture)	885	338	14	107	48	13	79	29	169	88
Meadow grass (average, about to bloom)	756	215	25	81	47	13	51	35	236	53
Clover, red (young)	878	322	21	257	80	16	106	19	25	32
Clover, red (about to bloom)	648	245	10	198	70	8	67	15	15	20
Clover (in bloom)	613	202	10	214	70	7	60	18	14	18

	T.	1	2	3	4	5	6	7	8	9
Clover, in bloom (leaves)...	774	211	16	346	70	10	66	12	19	24
Clover, in bloom (stalks)...	519	210	8	141	66	5	47	9	7	26
Clover, in bloom (bloom)...	616	227	15	148	60	12	100	13	12	29
Clover, white (just in bloom)	565	134	36	158	51	14	79	37	28	28
Lucerne	634	115	11	271	31	11	70	38	63	24
Sainfoin	495	137	18	181	32	6	50	14	39	18
Trifolium	549	126	46	172	33	11	38	14	89	20
Kidney Vetch	603	162	5	307	30	6	55	10	22	6
Tares	489	107	26	175	49	2	67	36	12	15
Peas (about to bloom).....	673	251	24	170	68	4	73	54	10	19
Buckwheat (in bloom)	739	230	18	301	98	12	39	27	9	5
Trefoil (common)	586	181	47	160	49	8	47	23	20	51
Birdsfoot	876	312	18	195	31	81	100	38	78	23
Mustard, white (not in bloom)	828	278	28	278	28	20	35	70	35	56
Savoy cabbage	1142	316	115	245	41	19	168	94	54	90
Cattle cabbage	903	304	76	182	34	7	70	139	10	81
Cabbage lettuce	1622	613	115	238	101	85	150	62	133	125
Cos lettuce	1170	295	416	137	50	14	129	46	34	49
Spinach	1237	201	431	146	78	41	124	84	56	70
Mangel tops	1458	239	481	153	124	20	76	76	48	241
Swede tops	1489	210	52	490	52	87	151	174	160	113
Kohlrabi tops	1118	212	53	335	50	65	89	129	98	87
Turnip tops.....	1066	245	97	343	44	14	79	97	44	115
Carrot tops	1037	125	101	400	41	32	51	91	121	75
Potato tops	876	177	79	252	131	26	64	51	36	60

	T.	1	2	3	4	5	6	7	8	9
Jerusalem artichoke tops	652	138	9	223	58	6	31	9	160	18
Onion tops	946	277	53	325	39	30	38	40	94	50
Leek tops	845	325	55	174	36	50	61	33	58	53
Chives tops	828	259	35	172	44	12	126	103	25	52
Dandelion tops	1159	460	122	235	99	10	93	27	82	31
Stinging nettles	1213	382	29	341	85	57	93	99	48	79
Dill (whole plant)	836	168	73	187	67	6	118	117	14	86
Sprouted wheat tops†	885	302	10	43	13	7	65	24	348	67
Sprouted oat tops†	728	301	26	48	22	5	62	31	202	31
Sprouted barley tops†	856	356	24	70	33	5	66	36	208	58
Sprouted rye tops†	630	246	4	45	19	6	90	8	190	22
Maize, leaves	799	133	28	104	37	12	46	17	410	12
Maize, leaves and stalk	652	239	8	73	24	3	31	1	244	29

NOTE.—The salts contained in hay made from the above, may be taken as being identical with those of the green foods from which the hay was made.

† Sprouted on soil

CHAPTER II.

The object of this book is to draw attention to the importance of the mineral salts, at the same time the subject would not really be complete did I not also deal with the organic components of the foodstuffs. These, as will already have been gathered from what has been said, are divided into three groups namely:

Proteid substances (Albumen, Casein, Fibrine, etc.)
Fats (Fats and Oils).
Carbohydrates (Starch, Sugar, Cellulose, etc.)

Of the Proteids we know that they are the flesh formers, of the Carbohydrates that they are the heat and work producers, and of the Fats we know that they act as a kind of reserve to the carbohydrates and can possibly, if need be, be dispensed with altogether.

They are usually enumerated in the order in which I have tabulated them, but I will deal with them in the reverse order, taking the Carbohydrates first. Of these we know that they are that component which represents the fuel of the engine, producing heat and being the means of producing all bodily activities. This production of heat and work is brought about by their combustion, that is a slow form of burning, a process to which I have already had occasion to refer to more particularly in my book entitled "How to Hatch 100 chickens with the assistance of one broody hen."* Reference to this process has also

*"How to Hatch 100 chickens with the assistance of one broody hen."—Of the author, Arthur Bossert, Caldecote, Cambridge. 1/- net, by post 1/2.

been made in the preceding chapter, but as it is not directly connected with the Inorganic substances, that is the salts—these not being combustable, or, in other words, do not burn—but with the Organic substances—which do burn—I will try and explain what combustion itself is and how the combustion of the Organic substances in the animal takes place. Combustion really consists in the devouring and destruction and general transformation of matter by minute organisms. This process is not possible without the production of motion on the part of those minute organisms, that is to say they cannot perform that process of devouring and destroying without exertion and motion, just as it is not possible for men to work without moving. The devouring, then, is the combustion, and the motion only an accompanying phenomenon; but it is just this motion produced by the minute organisms that is the objective of eating. Eating,—that is, the eating of the Carbohydrates at all events—is not performed with the object of possessing those Carbohydrates, but merely with the object of feeding the minute organisms referred to, in order that they may produce motion when they, in turn, consume and destroy that substance. This motion is turned to account in two distinct ways by the master organism (the animal) that originally appropriated the food. Firstly it is made use of as heat—heat being the sensation due to being struck by innumerable minute particles in motion,—and secondly, it is employed to produce motion in another form, namely, the motion of the limbs and different parts of the body of the master organism. The motion produced by the minute organisms is thus either put to use in the form in which the minute organisms produced it, that is as rapid motion of minute particles widely distributed or it is directed to act in such a way as to produce slower motion of more bulky objects—the limbs and the like. And it is these two forms of motion that are the ultimate objects in view when appropriating

and consuming the substances called Carbohydrates.

Interesting it is to note that the Carbohydrates—Starch, Sugar, etc.—are found in the bodies of plants only—that is in quantity. Surprising, however, it is not for, as plants do not move or produce heat—at least only to a limited extent—they have no occasion to have it consumed in their system by minute organisms, and it thus accumulates, building up their bodies. That they are not to be found in the animal system, on the other hand, or only in small quantities, is not to be wondered at, for all the animal wants from the Carbohydrates is the motion resulting from their combustion. For the substance of the Carbohydrates or, to be more correct, for the refuse left over from the Carbohydrates, it has no further use, and this is therefore voided from the system.

The fats, as has been stated, may be regarded more as a reserve substance to the Carbohydrates. They can be absorbed and deposited in the form in which they exist in the bodies of other animals, without more ado—at least it is believed that that is possible under certain conditions—but as a rule they first undergo a transformation. In the case of vegetable fats such change is a necessity, for vegetable fats differ from animal fats in their composition, and can for that reason not be deposited unless that composition has changed. But they can also be produced from Carbohydrates and Proteid substances. They are of a more concentrated nature than the Carbohydrates producing, as they do, from two to two-and-a-half times the heat of these, the exact amount depending on the nature or quality of the fat; and it is for this reason that they are more sought after by man and beast. Doubtlessly, too, the fact of their being of a more concentrated nature than the Carbohydrates is the reason why they are used for storing up in the animal system in times of plenty, to be consumed in times of scarcity. And this no doubt is also the reason why eggs contain fat only and no, or practically no, Carbohydrates, it being important that the eggs contain the greatest

amount of nourishment in the smallest compass possible. But for no other reason is the presence of fat in the body necessary unless it be for the formation, in the case of some animals, of a layer near the outer surface, to give protection against the influence of cold surroundings. In that case the slow combustion going on within that layer, acts as a cloak, constantly producing a small amount of heat and thereby counteracting the effect a colder atmosphere without, would have upon the more delicate organs of the animal within. Another minor role played by the fats is that of lubrication.

Fat being of a more concentrated nature it would appear to be advantageous to employ it at all times as a producer of heat and energy, instead of the Carbohydrates. So possibly it might, but Fat is not procurable in nature as easily as the former—it is more expensive, so to speak,—and for that reason it is usually more profitable to supply the heat and work producing substances in the form of Carbohydrates. At times, however, it may be more profitable to supply the heat producing element in the form of Fat, especially is that so in the case of the laying hen, whose eggs contain a very large proportion of pure fat—observe the figure 258 appertaining to the egg, in Table II. It would be very unwise to expect her to expend her energies in the conversion of other substances into fat instead of employing that energy to better advantage in the production of the eggs themselves. At the same time not much more fat than that actually needed for the eggs will have to be given, for the constitution of the hen is not adapted to the assimilation of all the heat producing elements in the form of fat. For her own use the bulk will have to be suplied in the form of Carbohydrates

An egg, as we shall find, is a commercially very valuable substance as compared with most others, it will therefore be more economical to supply her with fat, as such, for the formation of her eggs for, although this is ordinarily high-priced as

compared with Carbohydrates, it must be considered cheap in the circumstances. We shall therefore do well to supply the laying hen with a goodly proportion of fat in her diet; a hen that is not laying, however, or a pullet that one is desirous of keeping from laying had best be allowed to expend her energies in producing heat from the cheaper heat-producing substances, Carbohydrates.

Then as to the Proteids or flesh-formers, as they are called. Proteids comprise such substances as Albumen, Casein and Fibrine. This I have explained before, but I think it well to repeat such information as this at different times as it will not only make it unnecessary for the reader to refer back but cause it to be more firmly impressed upon his mind, should he not already be well acquainted with the various terms—and most people are not. It is most unsatisfactory, not to say unpleasant, to read about a subject that would otherwise be of interest and to find oneself in a maze of terms of which one does not properly know the meaning. This I wish to avoid in the interests of the reader, as also in the interests of the subject, and in order that the reader may be thoroughly conversant with the above terms I will further explain that the whole of the three substances classed as Proteids are very closely related, differing but slightly in their composition, and that the Albumen is that substance of which the white of the eggs is chiefly composed, the Casein the substance found in cheese, and the Fibrine a substance usually transformed from Albumen and composing the muscular portion of the flesh.

Now I will explain the Table—Table II, the red table—and its uses. Here, as in the case of Table I, it has been assumed that a ton of each of the foodstuffs is at disposal, and as the organic substances are contained in these in greater quantity than the salts, I am not giving them in ounces as there, but in pounds. As before, I am assuming the foodstuffs to be in the form in which the hen will consume them, that is, mixed up in the proportion of one part

of solids to three parts of water, whereby it becomes possible to compare the various foodstuffs figure for figure.

The first column, marked "A," contains figures relating to the Proteids; column 2, marked "B," those referring to the Fats; and in the third we find the figures for the Carbohydrates and Cellulose given together. Cellulose is another term that has not been mentioned before, it being of subordinate importance. Certain parts of the fibre of plants are called Cellulose, and it is the substance which we see in its almost pure form in cotton and linen. Its heat giving power is about the same as that of Starch. The other columns do, as yet, not interest us.

It will be noticed that the words "Effective Constituents" have been placed above the words Proteids, Fat, Carbohydrates. The meaning of this I must exlain.

Such a foodstuff as Oats, for instance, contains 67 lbs. of Proteids in one ton of total foodstuff, that foodstuff consisting of one part of solids and three parts of water; in other words 5 cwt. of solids contain 67 lbs. of Proteids. Now it must not be imagined that the whole of these 67 lbs. are digested by the animal consuming them, nor is the amount digested by different kinds of animals the same. The reason why the whole amount is not digested is partly due to the nature and construction of the foodstuff and partly due to the nature of the animal consuming it. But we are here not interested in the question as to how various kinds of animals deal with various kinds of foods, but the average figures for all kinds of animals only for, as experiments have not been conducted with fowls, we shall have to make use of the average figures arrived at through experiments with other animals.

And as the divergence in the case of the other animals is not very great generally speaking we may assume that the figures also apply to fowls. Possibly fowls may digest one kind of foodstuff better than the average figures given would have it, others

possibly not as well, but that I do not propose taking into consideration and leave the reader to make any little alteration he may think fit in connection with any foodstuff he considers particularly suited to the nature of fowls or the reverse. All my figures will therefore be based on average figures arrived at by experiment with such animals as horses, cows, pigs and sheep.

I have just mentioned figures appertaining to oats. I stated that this cereal contains 67 lbs. of Protein for every ton of foodstuff. Of these 67 lbs. only 52 lbs. are digested. Taking potatoes we find that out of 47 lbs. of Protein only 25 lbs. are digested. And to take another substance, Grass (just in bloom) we find that of 67 lbs. of Protein, 45 lbs. are digested. And in the case of the hay made from this same grass we find that although the total Protein is about the same, only 35 lbs. are digested. The figures relating to the Protein of these four foodstuffs thus are; and I should state that the third column does not concern us at first:

	Total Protein.	Digestible Protein.	Effective Protein.
For Oats	67	52	49
Potatoes ...	47	25	25
Grass	67	45	39
Hay	66	35	23

which shows that in the one case 52—or 78 per cent.—were digested; in the second 25—or 53 per cent; in the third 67 per cent.; and in the fourth again 53. From this it is evident that tables giving the total quantity of Protein only are very misleading. But the percentage digested is not all that we have to consider. Some foodstuffs necessitate a greater expenditure of energy on their mastication and assimilation than others do and the total loss of effective work is very considerable in some instances. In the case of Oats this loss due to mastication and digestion is 5 per cent; for Potatoes it is practically nil for Grass it is 13 per cent., and in the case of Hay, as may be expected, the loss is

very considerable. It is no less than 33 per cent. Each figure has thus experienced a further drop. If the fall in the effective value were in the same ratio in each case it would not so much matter, but as that is by no means so it follows that this point must also be taken into consideration. I have therefore determined what I am calling the "Effective Constituents" of each foodstuff, and as the figures given represent the final value of such constituent after deduction has been made for the two kinds of losses experienced during the whole process of digestion, these figures may be taken as representing the true respective values for the different foodstuffs tabulated.

In column A of our red table we shall therefore find the figure 49 for Oats; 25 for Potatoes; 39 for Grass, and 23 for Hay made from that grass. And it is these figures that are given above in the third column headed "Effective Protein."

That is as regards the Proteids. With the Fats and Carbohydrates I have dealt similarly.

By comparing these figures for the various foodstuffs we obtain a very good idea as to their respective merits and values. But we can still further improve on this method of comparing them, for there is a way by which the Proteids, Fats and Carbohydrates may be reduced to one common term. We know that one part of the Proteid produces nearly the same amount of heat—actually 94 per cent.—as one part of Starch produces (Starch being one of the Carbohydrates); also that one part of fat produces from about 2 to 2½ times the amount of heat produced by Starch (for Grass, Hay and Roots the figure is 1.91; for Cereals, Bran and the like 2.12; for Oilseeds, such as Linseed, also for animal products it is 2.41) and finally that all the Carbohydrates may be taken as being equal to Starch as regards heat production. We can therefore recalculate our figures for Protein and Fat in such a way that they represent equivalents of Starch. In the case of Oats, for instance, we shall obtain:

Protein	49 x ·94	= 46	Starch equivalents.	
Fat	25 x 2·12	= 53	,,	,,
Carbohydrates	291 x 1	= 291	,,	,,
or a total of		390	,,	,, and

that, it will be found is the figure given in Column D for Oats. As Starch-equivalent and Feeding-value may be taken as being identical, to all intents and purposes, the figures in column D represent the feeding values of the various foodstuffs contained in our list. And there we may compare them. Thus we find Wheat 468; Rye 469; Barley 479; Oats 390, and so forth. Of altogther special interest in our particular case is the Starch equivalent of the Egg itself, the interest centreing in the fact that it comes out at the top of the list. I do not mean that it is at the top of the list, where, of course, I have placed it in order that everything else may be compared with it, but that it works out higher, as regards nourishing value (884), than any other foodstuff on the list, even beating such a food as meat by a considerable number of points. This is a most interesting point, not only to us who are interested in the hen, but also to the consumer. And there is yet another interesting point—one of even almost greater interest—in connection with the nourishing value of eggs. That eggs have great nourishing value is allowed by all; there are, however, opponents to the use of eggs as an article of diet, their argument being that eggs cause such complaints as rheumatism, and the like; that eggs may also have a reducing effect on the system. But they forget that there are "Eggs" and "Eggs"; that is to say they have never considered what we are at present considering, namely, the difference that exists between eggs. We have learnt that one egg will hatch, whereas another will not. We have also learnt that in one case the embryo chick in the egg is poisoned owing to the inability of the egg, through want of Sodium salts, to discharge the carbonic acid gas which is being produced during

incubation. Again we have learnt that the free Sulphuric acid produced from the Sulphur in the Albumen has a most destructive effect on the young chick owing to its (the sulphuric acids) peculiar voracity, that is to say that it has this destructive effect if sufficient alkaline matter in the way of mineral salts is not present to prevent it. We have also learnt that the liver cannot perform its function and fails if the salt called Sodium Sulphate is not in evidence in sufficient quantity; and so forth. Now combustion during the process of digestion is the same as combustion going on within an egg during incubation, but an "Egg" is not necessarily an "Egg" —at least not in our sense; if then the want of balance between the organic substances and the salts kill the chick in the one case it is not surprising if it kills us in the other, for poisoning by carbonic acid gas amounts to about the same thing as acquiring rheumatism; and having the liver put out of action in the one case is the same thing as having the liver put out of action in the other.

But we have learnt that in the one case a healthy chicken is produced. Is it necessary to say more? He is a blind man who cannot see in broad daylight!

One of the next in feeding value is, of course, our old friend the Milk, but this time the sisters are somewhat in the rear; at the same time it is surprising how high up they are on the list. That milk, with its perfectness in the way of salts, and its high feeding value, should be a good foodstuff is however not surprising, and we are not likely to find a better, but, as I remarked on a former occasion— one must not ask the price. At least not at present; it will be time for that a little later on when our admiration has worn off somewhat.

Second, to the egg itself, the milk, however, is not; this place is filled by Rapeseed with a score of 794, and between this and Milk (724) we still find Poppy seed (781) and Linseed (727). That these seeds should be so near the top is interesting, for these small seeds are special favourites with the hen.

Hemp seed with 644 is not very far behind. This and Poppy seed, also Rape seed, are good lime-seeds, all being in this respect far in advance of the larger grains such as Wheat and Oats. Of the Cereals, Meals, and Animal products all are high, especially Greaves, the last-named, of course, owing to the great amount of fat contained in it. But it is very one-sided. That the Green foods should work out so high will come as a surprise to many, but when we remember that cows do their best on grass we are more inclined to understand it. It is just in connection with the green foods that our deliberations regarding the natural proportion of water and solids in foodstuffs—3 parts of water to 1 part of solids—explain so much. Because these foods contain a large proportion of water and, forgetting that other foodstuffs, which contain less, have got to have it added, the green foods naturally have the appearance of being altogether inferior. In reality, however, they are not so very much lower. And that one should not forget. The Cabbages are almost as high as oats it will be found, and higher than Buckwheat. And we must not forget that the Cabbages are particularly rich in salts, especially Lime and Sodium. Those other Lime and Sodium plants: Pea-haulms, Dandelion and Cos Lettuce are also some of the highest. Even Mangel leaves are fairly high, as also Spinach.

The clovers in our list supply a point of interest. It will be noticed that the younger the plant, the higher the feeding value. The young clover supplies 365 values; when about to bloom this drops to 337 and finally when in full bloom only 267 feeding values are left. This is what happens in the case of all plants. The same thing may be noticed in the case of Pea-haulms as registered under Hay. Sprouted oats also supply a very acceptable figure—366. Jerusalem artichoke-leaves are somewhat remarkable and as they also show up well for lime they should not be wasted. But most remarkable of all is the Stinging-nettle plant. To fowls it cannot

be fed in the fullgrown state I believe; at least I have only given it when young; but in the dried state, as hay—if one can so call it—it is one of the most useful of plants. I have seen it mentioned in Continental writings as one of the very finest egg producers, but I doubt whether the writers knew the reason. If we look at that which stands to its credit in the third Table we shall begin to understand it. Such a plenitude of salts is possibly not found anywhere else. We here also find a pecularity not noticeable anywhere else, and that is that it is more valuable in the dried state than it is as a green food. The digestibility of the fat and the carbohydrates is so very much higher in the dry plant and accounts for the difference. Stinging-nettles are thus a most valuable food for fowls. They should be mixed up in the soft food.

But otherwise, on the whole, the various kinds of hay do not offer much attraction. The leaves of the Pea-plant as also those of the Clover find a certain amount of favour. These leaves are particularly rich in lime; in order that this point may be observed I have given some additional figures for clover in the Blue Table.

We have now dealt with the Effective Constituents of the various foodstuffs, having given the effective values of the Proteids, Fat, and Carbohydrates—that is those values which are finally left and appear as heat and work—and we have reduced the values to a common term which I have called the Starch-equivalent. One thing we now still have to determine, and that is how the various foodstuffs work out as regards Pounds, Shillings, and Pence. On going through the Starch-equivalent, as we have just done, and realising that one foodstuff costs more to buy than another, one naturally asks the question as to what one gets for ones money. In order that there may be no question as to this, I have prepared one more column—column E. Here the Starch equivalent that £1 will buy is given. I might, of course, have chosen any other

figure as the monetary basis—a shilling for instance—but I found that the figures representing the Starch-equivalent for 1/- were in many cases too small to be tangible. I therefore decided on £1 as the basis. In column F I give the price of each foodstuff per ton. To know what weight a quarter of the various cereals represents one almost needs to be a corn merchant, and as some things are priced at so much per cwt. and others at so much per stone I have thought it best to choose the ton as the common measure. As may be imagined it was no very easy matter to determine uniformly average prices, more especially as town prices and country prices vary somewhat, as also they do in different parts of the British Isles. However, I have endeavoured to strike the happy medium as nearly as possible; should, however, my figures not correspond with any reader's local prices he must add or deduct proportionate amounts from the Starch-equivalent my price buys. The Green foods I found it particularly difficult to price. What, for instance, is one to put down as the value of a ton of Cabbages or Carrot-tops, or such things at Stinging Nettles, Dandelion leaves, or Mangel leaves. This I found too large an order, to put it vulgarly, so I had to bethink me of a way how the problem could best be solved. It then occurred to me that such things as Cabbage leaves, Carrot tops, Mangel leaves, and the like were usually only waste matter—bi-products so to speak —and that their cost practically amounted to the value of the gathering. I then calculated that the price of grass mown with a lawn mower, works out at somewhere about 10/- a ton—feeding it to the fowls is, of course, the poultryman's work and has nothing to do with the production of the foodstuff—and so, all things considered, I felt it would be wisest to charge a uniform ten shillings for all the green foods, again leaving the reader to alter my final figures according to his particular case. In this way then the figures in column E have been evolved.

Now, to examine these figures. Those at the head of the column, referring to the hen and her production, make us blush, or, as we are the sellers, they may make us smile. Of course we hardly know as yet what the figures 14 and 5 mean, as representing the Starch-value received for £1, but when we look down the column we begin to realise that 14 and 5 are rather small quantities. Especially do we realise this when we see that of some substances 200 and more values can be bought for the same price. The Starch-equivalent of the egg and the flesh of the fowl—apart from the question of price—is certainly very fine, 884 and 596 proving them to be very fine things in small parcels; but the price is very fine, too. However, most human food is dear, and we, as hen rearers, may find solace on inspecting the figures for meat and milk—both taken at 3d. Meat taken at a shilling, for human consumption, really works out no better than the flesh of the fowl, milk, however, rather better; but when considered as food for fowls one will appreciate my former remark that it be better not to enquire the price.

But these figures—at least the one concerning the egg and the fowl—also help to explain another remark I made, namely the one regarding the supplying of fat in the food and not expecting the hen to produce it from other materials. At such prices we can certainly afford to pay high prices for the fat in the food.

Another point I should draw the reader's attention to is the difference between the Starch-equivalents obtained from the various meals produced by having whole corn ground at the millers and buying the meal as it is usually offered by the corn chandler. If one enquires the price of whole peas for instance, one may be told 8/- per cwt. If one enquires the price of Pea-meal, it is 10/- If one then enquires the value of the grinding, one finds that that works out at about 6d. per cwt. How this is, it is difficult to say, but doubtlessly

there is a mistake somewhere; but wherever the mistake may be it is better to buy the corn by the quarter and get the miller to grind it for sixpence. And the chances are that not as much of the flour will be sifted out, in this way, either.

But as regards meals I should make another remark, one of an opposite nature, and that is, that similarly as in the case of skim milk, the sifting out of the flour raises the percentage of salts in what is left. And again, that grinding adds, on an average, rather more than 10 per cent. to the digestibility of the corn; supposing therefore that the grinding costs 10s. a ton we shall do well by having any corn of which the original cost was more than £5, ground into meal. And the higher the price the greater the advantage of grinding. Were the price less than £5, we should be the loser as the gain in digestibility is only 10 per cent., the cost of grinding, however, more.

The last column of the table contains figures denoting the percentage of solids contained in each foodstuff, in its natural state. This column is of secondary interest only. The figures are necessary when calculating the Starch-equivalents obtainable for £1, that is, the value given in column E; and as this calculation may be of interest to some I append the formula according to which it is performed.

If x represents the Starch-euivalents given in column D,
y the percentage of solids in the natural substance,
z the value of the substance in shillings per ton (column F),
and E the Starch-equivalent purchasable for £1 —then:

$$E = \frac{x \times y \times \cdot 8}{z}$$

And taking Wheat as an example we have

$$E = \frac{493 \times 86{\cdot}6 \times \cdot 8}{165} = 196{\cdot}2$$

TABLE II.

TABLE II.

An analysis of the Organic Constituents of various Foodstuffs, the quantities given being in pounds per ton of Food made up of one part of Solids to three parts of Water ; also giving the Starch equivalents and the units of Starch equivalents obtained per Pound sterling.

Name of Foodstuff.	Effective Constituents.			Starch equivalents.	Starch equivalents per Pound sterling.	Price of Foodstuff in shillings per Ton.	Percentage of solids in the natural Substance.
	Protein.	Fat.	Carbohydrates.				
	A	B	C	D	E	F	G
Fowl's Egg (contents)	267	258	12	884	14	1333*	26.3
Flesh of Fowl	438	65	28	596	5	2240†	25
Blood of Fowl	505	5	1	488	4	2240†	20.7
GRAIN.							
Wheat (large).....	63	8	397	468	196	165a	86.6
Wheat (small).....	71	9	355	441	219	140b	86.6
Rye	60	7	400	469	233	140c	86.6
Barley	43	12	413	479	212	155d	85.7
Oats	49	25	291	390	180	150e	86.7

* 1 penny per egg.

† 1 shilling per pound.

a, 37/-; b, 28/-; c, 29/-; d, 30/6; e, 23/-; per quarter.

	A	B	C	D	E	F	G
Maize	46	25	431	527	304	120f	87
Rice	37	1	491	528	142	260	87.4
Dari	48	19	388	473	232	145g	88.9
Peas	124	6	335	464	199	160h	86
Buckwheat	52	11	278	350	152	160i	85.9
Tares	145	9	314	469	130	250j	86.7
Millet	45	19	359	441	89	350	88.5
Linseed	116	207	119	727	131	410	92.9
Hemp seed	80	173	151	644	151	310	91.1
Rape seed	94	251	94	794	150	390	92.7
Sunflower seed	71	171	110	590	111	390	92.5
Maw seed (Poppy)	89	245	106	781	116	500	92.8
Barley meal	62	14	388	476	196	170	86.8
Barley meal*	69	16	431	529	220	165	86.8
Pea meal	132	8	334	477	173	190	86.5
Pea meal*	137	8	372	516	209	170	86.5
Bean meal	150	9	294	457	175	180	85.5
Bean meal*	154	9	338	503	215	160	85.5
Wheat meal*	70	9	441	520	206	175	86.6
Wheat meal**	79	10	394	491	226	150	86.6
Maize meal	49	27	434	537	234	160	87
Maize meal*	51	28	479	586	313	130	87

f, 28/-; g, 31/-; h, 38/-; i, 29/-j, 60/- per quarter.

* Prepared from the whole grain. Prices have been taken as for the whole grain together with 10/- for grinding.

** Prepared from small wheat.

	A	B	C	D	E	F	G
Rice meal	43	65	245	423	204	145	87.4
Soya bean meal	179	10	138	327	157	150	90
Linseed-cake meal	168	46	173	430	158	190	89
Dec. cotton-cake meal	244	51	96	448	187	170	92
Groundnut-cake meal	243	51	126	476	196	175	90.2
Oatmeal or Groats	81	36	381	534	123	300	86.5
Sussex ground oats	56	27	392	502	139	250	86.5
Linseed meal*	127	228	131	800	141	420	92.9
Lentil flour	157	11	350	520	137	265	87.7
Bran	56	15	194	279	157	125	87.8
Middlings (Pollards)	79	19	364	477	247	135	87.8
Brewers' grains (dried)	78	34	169	314	176	130	91
Brewers' grains (wet)	71	30	174	308	234	25	23.8
Malt sprouts	89	7	185	284	160	125	88
Biscuit meal†	104	15	437	571	137	300	80
ANIMAL PRODUCTS.							
Cow's milk	150	155	210	724	32	225‡	12.3
Skimmed milk	209	44	252	552	60	75††	10.2
Machine-skimmed milk	219	12	272	506	52	75	9.7
Meat (waste)	379	95	7	592	21	560§	25
Fish refuse	309	48	2	397	142	50	22.4
Fish meal	289	40	0	367	87	300	88.2

‡ 3 pence per quart.
†† 1 penny per quart.
§ 3 pence per pound.

	A	B	C	D	E	F	G
Granulated meat	421	78	0	585	139	300	89.2
Greaves	345	145	0	674	128	380	90.5
Ox blood	478	6	1	463	151	50	20.4
Pig blood	498	4	1	479	175	50	23
Blood (average)	488	5	1	471	163	50	21.7
Dried blood	476	12	1	476	144	240	91
Green bone	175	26	0	227	80	160	70
ROOTS.							
Mangel	36	0	260	296	189	15	12
Swede	47	0	332	376	244	15	12.2
Kohlrabi	50	0	298	345	221	15	12
Turnip	38	0	276	311	176	13	9.2
Carrot	30	4	358	393	205	20	13
Potatoes (small)	25	0	423	446	297	30	25
Jerusalem Artichokes	25	0	403	427	233	30	20.4
Onions	28	2	404	433	24	200	14
FRUIT (Waste).							
Apples	11	0	453	464	560	10	15.2
Pears	9	0	399	408	550	10	17
Gooseberries	16	0	341	356	410	10	14.3
Plums	11	0	296	307	370	10	15.1
GREEN FOODS.							
Meadow grass (young)	64	10	252	330	529	10	20
Meadow grass (best pasture)	81	14	258	361	629	10	21.8

	A	B	C	D	E	F	G
Meadow grass (average, about to bloom)	39	8	253	303	609	10	25
Clover, red (young)	103	12	246	365	409	10	14
Clover, red (about to bloom)	75	13	244	337	431	10	15.9
Clover, red (in bloom)	49	9	205	267	431	10	20
Clover, white (just in bloom)	73	13	190	282	421	10	18.5
Lucerne (in bloom)	57	7	163	230	442	10	24
Sainfoin (in bloom)	65	10	218	297	453	10	19
Trifolium	52	12	213	288	428	10	18.5
Kidney Vetch	36	8	217	265	363	10	17
Tares (just in bloom)	90	9	192	294	367	10	15.5
Peas (about to bloom)	105	11	200	319	394	10	15.4
Buckwheat (in bloom)	48	9	230	290	350	10	15
Trefoil (common)	56	9	202	271	438	10	20
Birdsfoot	74	15	196	293	470	10	20
Mustard, white (not in bloom)	68	7	230	308	322	10	13
Savoy cabbage	97	12	258	371	383	10	12.9
Cattle cabbage	62	10	300	377	461	10	15.3
Cabbage lettuce	98	18	162	287	132	10	5.7
Cos lettuce	66	24	198	304	184	10	7.5
Spinach	85	17	162	271	251	10	11.5
Mangel tops	75	9	206	292	257	10	11
Swede tops	67	9	224	303	282	10	11.6
Kohlrabi tops	73	8	255	337	364	10	13.5
Turnip tops	69	7	226	304	246	10	10.2
Carrot tops	61	14	170	253	369	10	18.2

	A	B	C	D	E	F	G
Potato tops	21	4	157	183	338	10	23
Jerusalem Artichoke tops	38	9	291	343	886	10	32.3
Onion tops	86	16	201	312	291	10	11.8
Leek tops	90	16	208	322	320	10	12.4
Chives tops	86	16	212	323	468	10	18
Dandelion tops	76	16	217	317	368	10	14.5
Stinging nettles	123	13	170	309	424	10	17
Dill (whole plant)	62	23	188	288	396	10	17
Sprouted wheat tops†	40	10	229	286	400	10	17.5
Sprouted oat tops†	52	12	232	306	394	10	16.1
Sprouted barley tops†	42	7	224	278	423	10	19
Sprouted rye tops†	40	10	229	288	537	10	23.3
Maize, leaves and stalks	24	7	242	277	421	10	19
HAY, MADE FROM							
Meadow grass (young)*	33	7	194	239	192	85	85.2
Meadow grass (best)*	49	9	195	259	220	80	84.5
Meadow grass (average)*	23	4	178	208	178	80	85.7
Clover, red (average)*	34	7	147	192	151	85	83.5
Clover, white (average)*	40	10	174	230	172	90	84
Lucerne*	37	5	124	168	160	70	83.5
Sainfoin*	42	7	164	217	161	90	83.5
Trifolium*	36	4	152	193	183	70	83.3

† Biscuit meals vary considerably in composition.

* A * has been added to these so that the reader may remember that the figures apply to hay and not to greenstuff.

	A	B	C	D	E	F	G
Kidney Vetch*	25	4	157	188	168	75	84
Tares*	29	8	159	200	168	80	83.3
Peahaulm (just in bloom)* ...	79	8	148	236	198	80	84
Peahaulm (in full bloom)* ...	42	7	147	208	166	80	83.3
Buckwheat*	22	4	154	185	160	80	84
Trefoil*	54	7	156	221	175	85	84
Birdsfoot*	57	9	153	216	171	85	84
Mustard, white*	27	6	156	192	201	65	85
Potato tops*	16	3	143	163	147	80	90
Jerusalem Artichokes*	39	6	198	246	191	90	87.5
Stinging nettles*	72	28	202	323	286	80	88.6

* A * has been added to these so that the reader may remember that the figures refer to hay and not to greenstuff.

CHAPTER III.

Having studied the mineral-salt components of foodstuffs in Table I and the organic substances in Table II we shall wish to put what we have learnt to practical use; I have therefore evolved another table—Table III—in which the whole of the constituents of the various cereals, meals, greenstuff, &c.—just as they come from the corn chandler's or are brought in from the field—are given. Also the exact amount of water contained in the natural substances. Here we have the foodstuffs just as we buy, or otherwise procure them, and in the condition in which we shall have to use them; if we, therefore, wish to ascertain whether any diet we are using is well-balanced or not, we shall have to pick out the particular substances of which the diet is made up, multiply each one by the number of parts we are employing, and then add up the columns and see how matters stand.

Before dealing with this question more particuarly, however, I will make a few remarks about the table itself. It may be remembered that I spoke of tables of foodstuff usually given in books and other publications as being misleading. Quite apart from the fact that details of the salts are never given—at least not in the ordinary publications that reach the hands of poultry-keepers—and that the information as regards the digestibility of the organic substances is also often defective, there is the common failing of tabulating them exactly as they are found in nature, those containing a large percentage of water being placed side by side with those containing but little. In order to be able to make up rations it is, of course, necessary

that they should be given so, at the same time such particulars are very misleading, and doubtlessly to this superficial way of dealing with the question the disregard for certain foodstuffs as compared with others is due. In Table III they are given in this way, that is as they appear in nature —but, of course, the corrections for digestibility, &c., have been made, and the salts added—and by studying the table that which I allude to will be clearly seen. I must allude to this point again here or the reader—and of whom it cannot be assumed that he has the point as clearly before him as anyone who has made an intimate study of the question—will again make the very mistake against which I wish that he be warned. The advantage as regards feeding-value is certainly usually on the side of the cereal as compared with the green food, but the difference is not so very great as we can see on Table II. If we compare, for instance, Wheat and Grass on Table III, the figures read:

	Water.	Prot.	Fat.	Carbohy.
Wheat	300	218	28	1377
Grass	1790	51	8	201

The natural conclusion arrived at is that the Wheat is quite a number of times more valuable than Grass.

If we now compare them on Table II we find:

Wheat	63	8	397
Grass	64	10	252

and we begin to feel surprised. But really the most important comparison is that in which the monetary factor is brought in, and if we look up the point in column E of Table II we find that Grass has leaped right past Wheat, the figures being:

Wheat	196
Grass	592

Nor is this even the end of the matter, for the price we are taking for the grass includes for mowing it quite a number of times with a lawn mower; if grazed off, be it by cattle or fowl, we should not be paying half the amount, and grass

would run well past a thousand. Little wonder that cows are most satisfactory when on grass; but the poultry-keeper may also do well to bear the point in mind. But there is another reason why the cow does so well on grass, likewise the fowl—for it is erroneous to place the effect wholly to the credit of insect life—and that reason is to be found in Table I. The total salts are:

Wheat	188
Grass	764

For the details I refer the reader to the table itself, and would point out that if the money value were here also taken into consideration the difference would be much greater.

We will now pass on to the making up of rations.

If we wish to test any rations we may be feeding, all we have to do, as already stated, is to pick out the foodstuffs we are making use of, multiply each by the number of parts employed and add up the columns. But then, of course, we should need to have a standard of some sort wherewith to compare the figures obtained.

We will take the organic substances first.

In practice it has been found, and that chiefly in connection with the larger kinds of live stock, that the ratio of Proteids should vary between one part Protein to four parts of Fat and Carbohydrates taken together, and one part of Protein to seven parts of these. In the case of the fowl when not laying, a ratio of about 1 to 5 may be taken as representing the proportionate amounts of Protein to Fat and Carbohydrates taken together. As she is not producing eggs and there is also no need for her to accumulate fat it might appear that one part of Protein and five parts of the others alone would be what is wanted. But experiments with different animals have shown that the Protein is used to better advantage if about a fifth part of Fat accompanies it; the ratio of one Protein to a fifth Fat and

four and a half of Carbohydrates would therefore appear to be about what is needed, for, the fifth of Fat is equal to about one-half part of Carbohydrate. But what we want to find out is what she requires when expected to lay. The way I arrive at that figure is as follows: Roughly one may say that a hen in full lay consumes about 100 ounces of food per week—and by food I mean 25 ounces of solid matter to 75 ounces of water. Taking the weight of an egg at from two to two and a half ounces and assuming that the hen lays from four to five eggs per week, about ten ounces of effective matter would be required for their production. Now an egg is made up, approximately, of one part of Protein to one part of Fat—that is as regards the organic substances (see Table II), we shall therefore need to take ten parts, in the ratio of one part of Protein to one part of Fat, the remaining ninety parts—and which the hen requires for her own use, for her work in producing the egg, and so forth—in the other ratio. Thus we have:

	Protein.	Fat.	Carbohydrates.
10 parts in the ratio of	1	1	0 and
90 „ „ „	1	$\frac{1}{2}$	$4\frac{1}{2}$ or

in other words, the 10 parts will consist of 5 parts of Protein and 5 parts of Fat; and the 90 parts, of about 16 parts of Protein, 3 parts of Fat and 71 parts of Carbohydrates. Or given in tabular form:

	5	5	0
and	15·8	3·2	71
	20·8	8·2	71

or, roughly, the ratio of the organic substances in the foodstuff of a hen, laying from four to five eggs per week is one of: 20·8 to 8·2 to 71.

And this reduced to simpler figures, reads:

10 ... 4 ... 35

Now these figures I wish to draw particular attention to. As a rule ratios given as a basis for determining rations for live stock are expressed in such terms as 1 to 5, 1 to 6, and so forth, that meaning that one part of Protein is to be combined with 5 (or 6, &c.) parts of Carbohydrates, and the word Carbohydrates here representing the conjoint starch value of the Fat and Carbohydrates proper. This way of expressing the ratio is, in my opinion, faulty when applied to any kind of live stock, but far more so when applied to the laying hen. Such ratio might mean almost anything, and is doubtlessly due to the want of more careful thought. 1 to 5 might for instance mean 1 to 0 to 5—one Protein to, no Fat, and five Carbohydrates. It might also mean 1 to 1 to $2\frac{1}{2}$, for by conversion the 1 Fat gives $2\frac{1}{2}$ Carbohydrates; or it might even mean 1 to 2 to 0, that is all Protein and Fat, and no Carbohydrates at all. And in each case the ratio would be 1 to 5, as required by the formula. Surely then this way of treating the question is far too vague, especially so in the case of the hen. The figures I give above, namely:

	5	:	5	:	0
and	15·8	:	3·2	:	71

show very clearly the importance of the Fat, for the eggs, which only represent ten per cent. of the whole food, claim the bulk of the Fat as their share, no less than five parts out of the total of eight (roughly eight) being claimed by them. Were these five parts not to be had from the food the hen would have to produce them from the Carbohydrates as best she could, and that there is little wisdom in expecting her to do that every intelligent person will realise. At one point I called attention to the importance of not being niggardly in the supplying of Fat in the rations; I here draw the reader's attention to that remark.

Of course a hen may draw from the supplies stored up in her own body if the Fat is not supplied at the time; but that we do not want her to do; we

want, if possible, to keep her going, so to speak, without any strain being placed upon herself. Besides, her own supply would ultimately run short, and then she will need to rest unnecessarily to recuperate. We must therefore pay particular attention to the second figure, that referring to Fat.

In making the calculation and arriving at the ratio:

10 ... 4 ... 35

I assumed that four to five eggs were to be laid. As the quantity of Fat is so important, a little further study may still be of interest. Unfortunately it is very difficult to determine exactly how much more food a hen consumes for every additional egg laid per week, but by observation and rough calculation I find that it may be assumed that every egg laid per week requires one ounce of food (mixed in the normal proportion of water and solids—3 to 1) per day. Taking therefore 100 ounces as being right for four eggs, no eggs would mean 100 less 28 or say about 70 ounces, and seven eggs per week would necessitate the consumption of 100 plus 21 or say 120 ounces. But these must be regarded as quite rough figures, and I do not wish any special value to be attached to them; I only wish to use them in a little calculation in connection with the Fat of the rations. Assuming then that the idle hen requires 70 ounces of food and that every egg laid per week necessitates the addition of seven ounces of food per week we find, by a calculation, with the details of which I will not trouble the reader, that for every 100 parts of Protein consumed by the idle hen she requires 20 parts of Fat and 450 parts of Carbohydrates—and these figures the reader may recognise as those from which we originally started, namely, 1 to one-fifth, to 4½. A hen laying one egg and requiring an additional seven ounces of food for the production of the same would need a ratio of 100 to 26 to 421; a hen laying two eggs per week would require

more Fat still and less Carbohydrates and so on, and, given in table form, in which I have rounded up the figures for Fat so as to avoid making the table complicated by giving fractions, we have:

	Total Food.	Ratio of Protein to	Fat to	Carbohydrates.
Idle hen	70	100	20	452
Hen laying 1 egg...	77	100	26	421
Hen laying 2 eggs..	84	100	30	394
Hen laying 3 eggs..	91	100	33	375
Hen laying 4 eggs..	98	100	36	362
Hen laying 5 eggs..	105	100	39	347
Hen laying 6 eggs..	112	100	41	336
Hen laying 7 eggs..	119	100	42	327

and we see how the amount of Fat required increases whilst the figures referring to the Carbohydrates decrease. The former rise from 20 to 42, the latter fall from 452 to 327, and whereas the proportion of Fat to Protein is only one-fifth in the food of the idle hen it mounts up to more than double that in the case of the hen laying seven eggs per week. From this the importance of Fat in the rations of the laying hen should be clear, and it follows that if we want her to lay we must not stint her as regards Fat. But here I must again repeat what I have said on former occasion, and that is, that excess must be avoided. Right is Right and everything else is Wrong, and I think that if one keeps to my average figure of:

10 to 4 to 35,

observes one's fowls, and makes slight variations according to fancy, the result will be found to be highly satisfactory.

Therewith, then, we have determined the ratio for the organic substances, and we may go on to determine those for the Salts.

We have seen the importance of the Salts in the food of the hen, it will now be for us to find the proportion in which they should be contained in that food. This, however, is no quite easy matter, for there is no data whatever, dealing with the

subject, at disposal. In connection with human beings cow's milk has been taken as the standard as regards the salts, but that, in my opinion, cannot be accepted as such, for, if we study the whole question we shall find that milk contains more of such salt components, as Sodium and Lime, than are necessary for the adult; and that, for the reason that young animals have still to accumulate these substances.

I solve the problem in an entirely different way.

It might be suggested that the flesh of the animal be taken as the standard, or the blood, but that cannot be done as both of these contain accumulations of salts. If we were to take the blood as the standard for the Sodium we should find that the amount required in the food would be so great as to make it practically impossible to obtain it. But that the Sodium in the blood is made use of over and over again we know, it is therefore intelligible that the amount contained in the blood is not identical with the amount acquired in the food. A solution can therefore not be arrived at in that way.

If we consider that such animals as cattle and sheep can live entirely on grass and if we remember that the blood is fed direct by the food (the flesh is only fed by the blood) it may occur to us to examine the blood and grass and see in what proportion the salts are contained in the one and the other, for possibly they may halp us. As regards the Sodium for instance, we shall find that the blood of the ox—and it may here be mentioned that the components of the blood of the sheep are almost identical with those of the ox—contains, roughly, five to six times the amount contained in the average young and short grass as it is grazed; it is therefore evident that it is stored in the blood in this measure, or, at all events, we may say that the blood of the animal contains five to six times the quantity contained in the grass it grazes. And in the case of the Lime the reverse is

the case, the grass containing about twenty-five times the amount of Lime suspended in the blood. So we can say that the food of the ox, or sheep, should contain about a fifth to a sixth of the Sodium contained in their blood, and about twenty-five times the amount of Lime. The excess in the one case is, as we see, accumulated, and the other probably made to serve some useful purpose in the stomach and thereupon voided. Of the other salt-constituents some are accumulated, though only in a very slight degree as compared with the Sodium, and others are only put to more temporary use. Now we find that the composition of the blood of the hen is very similar to that of the ox and the sheep—that is, if we except Potassium and Phosphoric acid—and we may thus fairly conclude that the position as regards her blood and her food is very similar to that of the animals just named. In the total quantity of green foods we shall eventually have to give, we shall as a rule find Potassium in excess of what is wanted, and the same applies to Phosphoric acid and the cereals, flesh and fish foods; we shall therefore have little difficulty in supplying these. And the others we shall find are very much as we require them. We will therefore simplify the matter by dropping these out of our calculation and deal with columns 2 and 3 only. A fifth to a sixth of the Sodium contained in the hen's blood—namely, 94 ounces—that is to the ton—would be, roughly, 17 ounces; and twenty-five times the amount of Lime contained in her blood would be about 75 ounces. This would be for her own use; if, however she is to lay a matter of four or five eggs per week for any length of time and is at the same time not to rob her body in order to supply them with the requisite amount of salts, we shall have to provide the hen with additional quantities.

Now we have seen that of the 100 ounces of food a hen requires per week, about 10 go to the formation of the egg; 90 parts will therefore have

to be supplied in the measure required by the hen and 10 parts are needed by the egg. But the egg, as may be seen from Table III, contains 93 ozs. of Sodium and 44 ozs. of Lime. We shall therefore require nine-tenths of 17ozs. of Sodium for the hen (15 ozs.) and one-tenth of 93 (say 9) for the egg, or 24 ozs. of Sodium in all. And of Llme we shall require nine-tenths of 75 ozs. (67½ ozs.) for the hen, and one-tenth of 44 (say 4½) for the egg. 24 ozs. of Sodium and 72 ozs. of Lime will thus represent the minimum quantities one ton of food —as the hen consumes it—should contain. But one must, of course, not imagine that scrupulous exactness need be observed as regards these figures, a few ounces one way or the other will make no difference in practice. One cannot gauge the greenstuff so nicely, but in order that we be on the right side and have figures that are easily remembered we will take them at 25 and 75, the same ratio in which solids and water are contained in the foot. By working to this standard we shall find the health of the hens, as also the hatching qualities of the eggs perfect. Of that I have ample evidence, and, incidentally, I may also remark that such eggs are delicious to eat, the healthy fullness of the flavour being altogether different to that of the flat-tasting rheumatic egg.

As our table, Table III, gives the foodstuffs in tons and the salt-components in ounces, it will be simplest if we make our calculation as though we were mixing whole tons, for, after all, the tons only represent "parts," and at the finish there will be nothing to keep us from weighing our foodstuffs out in pounds, hundredweights or any other standard of weight.

TABLE III.

TABLE III.

An analysis of the Organic Constituents and Mineral Salts of various Foodstuffs, the quantities given being in pounds (for the Water and Organic Constituents) and ounces (for the Mineral Salts) per Ton of the Natural Substance.

Name of Foodstuff.	Effective Constituents.												
	Water. W	Protein. A	Fat. B	Carbo-hydrates. C	Potassium. K_2O 1	Sodium. Na_2O 2	Lime. CaO 3	Magnesium. MgO 4	Iron. Fe_2O_3 5	Phosphoric acid. P_2O_5 6	Sulphuric acid. SO_3 7	Silica. SiO_2 8	Chlorine. Cl. 9
	lbs.	lbs.	lbs.	lbs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.
Fowl's Egg (contents)	1649	281	271	13	71	93	44	4	1	151	1	1	36
Flesh of Fowl	1679	438	65	28	84	51	9	11	0	99	0	0	2
Blood of Fowl	1773	418	4	1	58	94	3	1	12	84	3	0	76
GRAIN.													
Wheat (large)	300	218	28	1377	205	14	21	80	7	306	3	14	3
Wheat (small)	300	246	31	1230	229	17	24	87	7	340	3	14	3
Rye	300	208	24	1387	212	10	21	76	7	316	10	10	3
Barley	320	148	41	1418	158	38	7	120	17	316	27	275	3
Oats	298	170	87	1098	191	21	38	80	14	281	17	424	10
Maize	291	160	87	1502	160	7	14	84	3	251	3	14	7
Rice	282	129	4	1717	91	14	10	42	4	192	0	10	0
Dari	249	171	68	1380	121	18	7	124	18	298	0	46	0

	W	A	B	C	1	2	3	4	5	6	7	8	9
	lbs.	lbs.	lbs.	lbs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.
Peas	314	428	21	1156	403	10	48	76	7	338	31	10	14
Buckwheat	316	179	38	955	103	28	21	62	7	215	7	3	7
Tares	298	503	31	1890	285	76	80	83	7	347	35	10	24
Millet	258	159	67	1270	120	14	7	103	14	241	4	582	4
Linseed	159	432	769	463	376	26	97	174	11	513	30	15	0
Hemp seed	199	292	630	551	343	18	402	98	15	620	4	204	15
Rape seed	163	349	931	349	364	22	215	174	19	630	33	22	4
Sunflower seed	168	263	633	408	215	96	100	163	22	479	30	193	33
Maw seed (Poppy)	161	349	935	349	275	22	714	193	7	635	37	67	7
MEALS													
Barley meal	296	216	49	1348	212	19	24	109	11	420	18	10	8
Barley meal*	296	240	56	1499	202	17	21	101	10	400	17	10	7
Pea meal	302	458	27	1157	423	11	52	82	8	356	32	10	15
Pea meal*	302	476	28	1291	406	10	49	76	7	340	31	10	14
Bean meal	320	511	32	1004	508	15	61	91	4	487	46	10	22
Bean meal*	320	528	31	1156	491	14	58	86	3	473	45	10	21
Wheat meal*	300	244	31	1535	205	14	21	80	7	305	3	14	3
Wheat meal**	300	274	35	1360	230	16	23	87	7	343	4	14	4
Maize meal	291	171	94	1511	175	8	16	90	4	264	4	16	8
Maize meal*	281	178	98	1669	160	7	14	84	3	251	3	14	7
Rice meal	282	150	228	857	217	49	49	340	10	840	7	393	4
Soya bean meal	224	645	36	498	451	11	61	90	7	371	29	0	4
Linseed-cake meal	246	600	164	616	457	29	160	296	21	596	61	239	14

* Prepared from the whole grain.

	W	A	B	C	1	2	3	4	5	6	7	8	9
	lbs.	lbs.	lbs.	lbs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.
Dec. cotton-cake meal.....	179	898	188	354	575	0	107	368	37	1113	29	199	0
Groundnut-cake meal	213	841	183	456	362	32	58	187	4	420	32	43	32
Oatmeal or Groats	302	281	125	1322	204	21	31	100	10	402	3	194	3
Sussex ground oats	302	194	93	1358	184	24	31	90	14	291	21	385	10
Linseed meal*	208	474	849	488	376	26	97	174	11	513	30	15	0
Lentil flour	276	552	39	1230	379	147	70	28	21	397	0	0	49
Bran	274	197	53	682	514	14	53	288	148	892	11	7	11
Middlings	274	277	67	1275	404	11	46	228	11	731	18	7	18
Brewers' grains (dried)...	202	284	124	615	55	15	208	157	7	548	0	493	0
Brewers' grains (wet)	1706	68	29	165	14	4	54	41	2	143	0	129	0
Malt sprouts	269	314	25	652	740	42	67	67	35	610	92	501	162
Biscuit meal†	359	352	51	1470	256	7	40	141	13	468	10	7	10
ANIMAL PRODUCTS.													
Cow's milk	1961	74	76	103	62	16	60	7	5	72	3	1	35
Skimmed milk	2010	84	18	102	75	22	60	6	6	79	4	1	33
Machine-skimmed milk ...	2020	85	5	106	79	23	63	6	6	83	4	1	35
Meat (waste)	1580	379	95	7	14	4	1	1	0	16	1	0	2
Fish refuse	1735	277	43	2	86	129	25	13	1	117	6	0	97
Fish meal	264	1019	141	0	254	382	1482	42	3	1382	18	0	287
Granulated meat	242	1505	278	0	32	18	132	21	79	257	7	4	11
Greaves	212	1251	526	0	19	11	78	13	47	154	4	3	7

* Prepared from the whole grain.

† Biscuit meals vary considerably in composition.

	W	A	B	C	1	2	3	4	5	6	7	8	9
	lbs.	lbs.	lbs.	lbs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.
Ox blood	1780	390	5	1	20	115	3	2	24	14	8	2	88
Pig blood	1723	458	4	1	78	98	5	5	29	41	4	1	95
Blood (average)	1751	424	5	1	49	107	3	4	26	28	6	1	91
Dried blood	202	1733	44	4	142	489	15	11	113	95	26	4	394
Green bone	663	494	73	0	11	3	2840	76	115	3570	3	0	168
ROOTS.													
Mangel	1970	17	0	125	178	52	14	15	3	28	11	8	28
Swede	1960	23	0	164	146	18	35	11	2	45	30	3	21
Kohlrabi	1970	24	0	143	126	21	39	22	11	78	31	9	18
Turnip	2030	14	0	115	149	32	35	12	3	42	36	6	15
Carrot	1950	16	2	186	117	68	36	14	3	41	21	8	15
Potato	1680	25	0	424	208	10	9	17	4	59	23	42	12
Jerusalem Artichokes	1780	20	0	329	202	56	14	12	15	59	20	42	16
Onion	1926	16	1	226	86	6	58	12	6	44	14	21	6
FRUIT (WASTE).													
Apples	1900	7	0	276	64	43	7	15	2	24	11	8	0
Pears	1860	6	0	271	61	10	9	5	1	17	6	2	0
Gooseberries	1920	9	0	195	60	13	19	9	7	30	9	4	1
Plums	1900	7	0	179	143	1	20	13	8	37	9	5	0
GREEN FOODS.													
Meadow grass (young)	1790	51	8	201	191	26	58	43	10	50	33	166	33
Meadow grass (best)	1750	71	12	224	295	12	93	42	11	69	25	147	77

	W	A	B	C	1	2	3	4	5	6	7	8	9
	lbs.	lbs.	lbs.	lbs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.
Meadow grass (about to bloom)	1680	39	8	253	215	25	81	47	13	51	35	236	53
Clover, red (young)	1926	58	7	138	180	12	144	55	9	59	11	14	18
Clover, red (about to bloom)	1881	48	8	155	146	6	126	45	5	43	10	10	13
Clover (in bloom)	1790	39	7	164	161	8	171	56	6	48	14	11	14
Clover, white (just in bloom)	1825	54	10	140	99	27	117	38	10	59	27	21	21
Lucerne (just in bloom)	1700	55	7	156	110	11	260	30	11	67	37	61	23
Sainfoin (just in bloom)	1814	50	8	165	104	14	137	24	5	38	11	30	14
Trifolium (just in bloom)	1824	39	9	158	93	34	127	24	8	28	10	66	15
Kidney Vetch	1858	24	5	147	110	3	208	20	4	37	7	15	4
Tares	1892	57	6	119	66	16	108	30	1	42	22	7	9
Peas (about to bloom)	1892	65	7	123	155	15	105	42	2	45	33	6	12
Buckwheat (in bloom)	1903	29	5	138	138	11	180	59	7	23	16	5	3
Trefoil (common)	1790	59	12	157	250	38	128	39	6	38	18	16	41
Birdsfoot	1790	59	12	157	250	14	156	25	65	80	30	62	18
Mustard (not in bloom)	1947	35	4	119	145	15	144	15	10	18	36	18	29
Savoy cabbage	1950	50	6	133	163	59	126	21	10	87	49	28	47
Cattle cabbage	1894	38	6	183	186	47	111	21	4	43	85	6	50
Cabbage lettuce	2110	22	4	37	140	26	54	23	19	34	14	30	29
Cos lettuce	2071	20	7	59	89	125	41	15	4	39	14	10	15
Spinach	1981	39	8	75	193	198	67	36	19	57	39	26	35
Mangel tops	1992	33	4	91	115	212	67	55	9	33	33	21	106

	W	A	B	C	1	2	3	4	5	6	7	8	9
	lbs.	lbs.	lbs.	lbs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.
Swede tops	1981	31	4	104	97	24	227	24	40	70	81	74	52
Kohlrabi tops	1937	38	4	137	114	29	181	37	35	48	70	53	47
Turnip tops	2009	28	3	92	100	40	140	18	6	32	40	18	47
Carrot tops	1831	45	10	124	91	73	292	30	23	37	66	88	55
Potato tops	1723	19	4	145	163	73	232	120	24	59	47	33	55
Jerusalem Artichoke tops	1515	49	12	376	178	12	289	75	8	40	12	207	23
Onion tops	1980	41	8	95	125	24	147	18	14	17	18	43	23
Leek tops	1960	45	8	103	161	27	86	18	25	30	16	29	26
Chives tops	1836	62	12	153	186	25	124	58	6	54	16	48	18
Dandelion tops	1914	44	9	126	267	71	136	58	6	54	16	48	18
Stinging nettles	1858	84	9	115	260	20	232	58	39	63	67	33	54
Dill (whole plant)	1858	42	16	128	114	50	127	46	4	80	79	9	59
Sprouted wheat tops	1847	28	7	160	211	11	30	9	5	46	17	244	47
Sprouted oats tops	1879	34	8	150	194	17	31	14	3	40	33	130	20
Sprouted barley tops	1814	32	5	170	270	18	53	25	4	50	27	158	44
Sprouted rye tops	1716	37	9	213	236	4	43	18	6	86	8	182	21
Maize (stalks and leaves)	1814	18	5	184	181	6	56	18	2	24	1	185	22
HAY, MADE OF													
Meadow grass (young)*	332	132	28	662	815	109	246	184	44	215	140	710	143
Meadow grass (best)*	347	166	30	660	1144	47	363	162	44	268	98	573	298
Meadow grass (good, average)*	320	82	14	610	736	86	278	161	45	175	120	809	182
Clover, red (average)*	370	114	23	492	1087	70	860	268	54	355	63	84	107

	W	A	B	C	1	2	3	4	5	6	7	8	9
	lbs.	lbs.	lbs.	lbs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.
Clover, white (average)*	359	135	34	587	451	121	531	171	47	266	125	94	94
Lucerne (average)*	370	124	17	415	385	37	906	104	37	234	127	210	80
Sainfoin (average)*	370	140	23	549	459	60	606	107	20	167	47	130	60
Trifolium (average)*	374	120	13	507	421	154	574	110	37	127	47	297	67
Kidney Vetch (average)*	359	84	13	528	545	17	1031	101	20	185	34	74	20
Tares (average)*	374	97	27	531	357	87	584	163	7	224	120	40	50
Pea haulms about to bloom)*	359	266	27	499	845	81	572	229	13	246	182	34	64
Buckwheat (average)*	359	74	13	519	773	61	1012	330	40	131	91	30	17
Trefoil (common)*	359	181	24	525	610	158	539	165	27	158	77	67	171
Birdsfoot*	359	171	30	515	1050	61	655	104	272	336	128	262	77
Mustard, white*	336	92	20	531	946	95	946	95	68	119	238	119	190
Potato tops*	224	58	11	516	637	285	912	473	94	230	184	130	216
Jerusalem Artichoke tops*	280	137	21	693	483	32	781	203	21	109	32	561	63
Stinging nettles*	253	256	99	717	1356	103	1206	302	202	330	352	170	280

* A * has been added to these so that the reader may remember that the figures refer to hay and not to greenstuff.

Now we have arrived at the final stage of our dissertations. All that remains is to make up the rations.

As Table III contains figures that are too large for practical use I have prepared an auxiliary table, a condense of Table III, and this I am calling Table IIIa. In this I give the Starch-equivalents obtainable for £1 as before in Table II, this simply to act as a guide as regards cheapness when selecting the foodstuffs. And the Effective Constituents I have reduced to one twenty-fifth of the actual values given in Table III. Of the salts I have given those of column 2 and 3 only. For practical purposes no more is necessary, and Table IIIa gives all that is wanted.

Ordinarily green food is not given in anything like sufficient quantities, not even by those who make a point of supplying it liberally. As regards the proportion of greenstuff and other foodstuff I allow myself to be guided by the simple rule that one-half of the total foodstuffs should be greenstuffs. This amount hens will eat up readily; I have records which show that they will eat as much as two-thirds greenstuff to one-third cereals, &c., especially if water is withheld during the morning.

As to the determining of the rations then.

In the first place we shall have to consider in what way the fowls are being kept. If on free range and during summer months we may assume that about half the food consists of grass and similar herbage, especially if no dry corn is given in the morning whereby drinking would be encouraged. To give a lot of dry corn in the morning is a mistake. It is quite unnatural, and apart from the fact that it militates against the more natural way of acquiring moisture—and with it the salts—it has other disadvantages that do not concern us here. We must always aim at supplying moisture by the medium of green food as much as possible. If kept on intensive lines, everything will have to be supplied. I will therefore deal with the question

under the latter supposition; the rations for birds on free range may be gauged from the figures obtained in this way.

One-half the food then is to be greenstuff, the other half corn and meat food. But we have another point to consider, and that is that the ratio of the organic substances will not be exactly the same in winter as in summer, more heat-giving substance—Carbohydrates—having to be supplied in winter. The general ratio, as we determined it, was:

10 ... 4 ... 35

For summer use we shall not be far wrong if we alter it to:

10 ... 4 ... 30

and for winter use to:

10 ... 4 ... 40

But I will here base a calculation on the general ratio of 10—4—35.

On referring to Table IIIa we shall first of all pass our eye down the first column, that dealing with the Starch-equivalent obtainable for £1—for, the price, if compatible with the other essentials is of first importance. At the same time we must also keep our eye on the fifth and sixth columns. But here I must make another interruption. I am of opinion that not as much large hard corn should be given as is universally done, and that what grain is given should, as much as possible, be of the small variety of seeds. This it will be found also works in very well with our endeavour to supply the necessary amount of fat, small seeds such as Rape seed, Hemp seed, also Poppy and Mustard seed being very rich in fat. Of the organic substance of Mustard seed I am unfortunately unable to give an exact analysis (of the salts the analysis will be found in Table I), but from what data I have it would appear that the organic constituents are very similar to those of

TABLE IIIA.

TABLE IIIa.

Giving the Effective Organic Constituents of the foodstuffs contained in Table III but reduced to $\frac{1}{100}$th the values; also the Sodium and Lime components there given as well as the Starch-equivalents per £1 given in Table II.

Name of Foodstuff.	Starch-equivalent per £1. E	Protein. A	Fat. B	Carbohydrates. C	Sodium. Na_2O 2	Lime. CaO. 3
GRAIN						
Wheat (large)	196	9	1	55	14	21
Wheat (small)	219	10	1	49	24	31
Rye	232	8	1	55	10	21
Barley	212	6	2	57	38	7
Oats	150	7	3	44	21	38
Maize	304	6	3	60	7	14
Rice	142	5	0	69	14	10
Dari	232	7	3	55	18	7
Peas	199	17	1	46	10	48
Buckwheat	152	7	2	38	28	21
Tares	130	20	1	76	76	80
Millet	89	6	3	51	14	7
Linseed	131	17	31	19	26	97

	E	A	B	C	2	3
Hemp seed	151	12	25	22	18	402
Rape seed	150	14	37	14	22	215
Sunflower seed	111	11	25	16	96	100
Maw seed (Poppy)	116	14	37	14	22	714
MEALS						
Barley meal	196	9	2	54	19	24
Barley meal*	220	10	2	60	17	21
Pea meal	173	18	1	46	11	52
Pea meal*	209	19	1	52	10	49
Bean meal	175	20	1	40	15	61
Bean meal*	215	21	1	46	14	58
Wheat meal*	206	10	1	61	14	21
Wheat meal**	226	11	1	54	16	23
Maize meal	234	7	4	60	8	16
Maize meal*	313	7	4	67	7	14
Rice meal	204	6	9	34	49	49
Soya bean meal	157	26	1	20	11	61
Linseed-cake meal	158	24	7	25	29	160
Decorticated cotton-cake meal	187	36	8	14	0	107
Groundnut-cake meal	196	34	7	18	32	58
Oatmeal or Groats	123	11	5	53	21	31
Sussex ground oats	139	8	4	54	24	31
Linseed meal*	141	19	34	20	26	97

* Prepared from the whole grain.

** Prepared from small wheat.

	E	A	B	C	2	3
Lentil flour*	137	22	2	49	147	70
Bran	157	8	2	27	14	53
Middlings (Pollards)	247	11	3	51	11	46
Brewers' grains (dried)	176	11	5	25	15	208
Brewers' grains (wet)	234	3	1	7	4	54
Malt sprouts	160	13	1	26	42	67
Biscuit meal†	137	14	2	59	7	40
ANIMAL PRODUCTS.						
Cow's milk	32	3	3	4	16	60
Skimmed milk	60	3	1	4	22	60
Machine-skimmed milk	52	3	0	4	23	63
Meat	21	15	4	0	4	1
Fish refuse	142	11	2	0	129	25
Fish meal	87	41	6	0	382	1482
Granulated meat	139	60	11	0	18	132
Greaves	128	50	21	0	11	78
Blood (average)	163	17	0	0	107	3
Fried blood	144	69	2	0	489	15
Green bone	80	20	3	0	3	2840
ROOTS.†						
Mangel	189	1	0	5	52	14

* Prepared from the whole grain.

† Biscuit meals vary considerably in composition.

† For every three parts of Roots or Greenstuff, one unit of Fat must be added to the total Fat when calculating rations.

	E	A	B	C	2	3
Swede	244	1	0	6	18	35
Kohlrabi	221	1	0	6	21	39
Turnip	176	1	0	5	32	35
Carrot	205	1	0	7	68	36
Potatoes (small)	297	1	0	17	10	9
Jerusalem Artichokes	233	1	0	13	56	14
FRUIT (WASTE).						
Apples	560	0	0	11	43	7
Pears	550	0	0	11	10	9
Gooseberries	410	0	0	8	13	19
Plums	370	0	0	7	1	20
GREEN FOODS.†						
Meadow grass (young)	529	2	0	8	26	58
Meadow grass (best pasture)	629	3	0	9	12	93
Meadow grass (average)	609	2	0	10	25	81
Clover, red (young)	409	2	0	6	12	144
Clover (about to bloom)	431	2	0	6	6	126
Clover (in bloom)	431	2	0	7	8	171
Clover, white (just in bloom)	421	2	0	6	27	117
Lucerne (just in bloom)	442	2	0	6	11	260
Sainfoin (just in bloom)	453	2	0	7	14	137
Trifolium (just in bloom)	421	2	0	6	34	127

† For every three parts of Roots or Greenstuff, one unit of Fat must be added to the total Fat when calculating rations.

	E	A	B	C	2	3
Kidney Vetch	363	1	0	6	3	208
Tares	367	2	0	5	16	108
Peas (about to bloom)	394	3	0	5	15	105
Buckwheat (in bloom)	350	1	0	6	11	180
Trefoil (common)	438	2	0	6	38	128
Birdsfoot	470	2	0	6	14	156
Mustard, white (not in bloom)	322	1	0	5	15	144
Savoy cabbage	383	2	0	5	59	126
Cattle cabbage	461	2	0	7	47	111
Cabbage lettuce	132	1	0	1	26	54
Cos lettuce	184	1	0	2	125	41
Spinach	251	2	0	3	198	67
Mangel tops	257	1	0	4	212	67
Swede tops	282	1	0	4	24	227
Kohlrabi tops	364	2	0	5	29	181
Turnip tops	246	1	0	4	40	141
Carrot tops	369	2	0	5	73	292
Potato tops	338	1	0	6	73	232
Jerusalem Artichoke tops	886	2	0	15	12	289
Onion tops	291	2	0	4	24	147
Leek tops	320	2	0	4	27	86
Chives tops	468	2	0	6	25	124
Dandelion tops	368	2	0	5	71	136
Stinging nettles	424	3	0	5	20	232

‡ Sprouted on soil.

	E	A	B	C	2	3
Dill (whole plant)	396	2	1	5	50	127
Sprouted wheat tops‡	400	1	0	6	11	30
Sprouted oat tops‡	394	1	0	6	17	31
Sprouted barley tops‡	423	1	0	7	18	53
Sprouted rye tops‡	537	1	0	9	4	43
Maize (stalk and leaves).....	421	1	0	7	6	56
HAY, MADE FROM						
Meadow grass (young)*.....	192	5	1	26	109	246
Meadow grass (best)*	220	7	1	26	47	63
Meadow grass (average)*	178	3	1	24	86	278
Clover, red*	151	5	1	20	70	860
Clover, white*	172	5	1	23	121	531
Lucerne*	160	5	1	17	37	906
Sainfoin*	161	6	1	22	60	606
Trifolium*	183	5	1	20	154	574
Kidney Vetch*	168	3	1	20	17	1031
Tares*	168	4	1	21	87	584
Pea haulm*	198	11	1	20	81	572
Buckwheat*	160	3	1	21	61	1012
Trefoil*	175	7	1	21	158	539
Birdsfoot*	171	7	1	21	61	655
Mustard, white*	201	4	1	21	95	946
Jerusalem Artichoke leaves*	191	5	1	28	32	781
Stinging nettles*	286	10	4	29	103	1206

‡ Sprouted on soil.

* A * has been added to these so that the reader may remember that the figures apply to hay and not to greenstuff.

Rape seed and Poppy seed. That is in the white variety of Mustard. The brown variety contains only about one-half the fat, its use as a condiment doubtlessly being due principally to the fact that a small proportion of the oil it contains is of a volatile nature, giving off the pungent fumes characteristic of ordinary table-mustard. My reasons for not giving as much hard corn as is usually given is twofold, the one reason being that it forces the fowls to drink, the other that corn in the form of meals provides more nourishment than it does in the whole state, and that for the reason that it is more digestible. The reason occasionally put forward for giving hard corn at the evening meal is that it lasts the fowl longer through the night. If that means that it taxes the digestive organs for a longer period, that would appear to constitute a disadvantage instead of an advantage; we have also to consider whether the hen can make full and proper use of a large mass of dry food if unable to add water, for water she cannot add at night. An argument in favour of hard corn is, that the effect of the harder substance is a stimulating one as regards digestion. But grit may possibly perform that function equally as well.

The remark is not unnatural that seeds are a natural food of the hen. Seeds are doubtlessly a natural food for her in the autumn, but in the spring, at the time when she is laying, there are none to be had, at least not hard seeds, for what she actually does find, has sprouted and is of a tender and succulent nature. Hard seeds are doubtlessly the right food in the autumn and winter, for the bulk of them contain a quantity of heat forming matter and some of the small seeds contain an abundance of fat. This comes in just right for storing up in the hen's body for use during the winter and keeping out the cold. The more, therefore, we study the question, the more shall we come to the conclusion that succulent foods and foods such as meat, fish meal, fish refuse and blood

—the two first-named in moderate quantities—provide a far better approximation to her natural diet during spring and when she is laying than does hard corn. I therefore select my rations in such a way that a great proportion of the foods can be employed in the form of mash. Dry bran, in hoppers, I also give sparingly. Bran does not work out as a profitable food (possibly owing to its more limited digestibility) and may, according to my experience, be more profitably replaced by a root and pollards mash, a mash made of pulped roots and pollards or middlings. For this I employ a special form of hopper, but as the description of such apparatus as this is quite outside the scope of the present subject I must leave it to be dealt with in a work I am preparing in connection with rearing.

It will be noticed that some of the rations given contain Bran nevertheless. This has been given with the idea that it may either be employed in the mash, and to assist in making that more crumbly, or for hopper-feeding if desired. But I do not wish the reader to suppose that I am recommending the rations given for any special reasons apart from the question of balancing. Everyone has his particular fancies and will choose according to these. The rations I am giving have actually been chosen quite at random.

When starting on the task of making up the diet we shall very soon have discovered the cheapest foods, and these we shall lay down as a basis for the rations; but we shall also find it necessary to choose such foodstuffs as Lentil flour for instance, which is very rich in Sodium, or we shall have to expect more from the green foods in this respect than they are able to supply. The mash ingredients I usually deal with first, the corn I take next, and then add about as many parts of greenstuff as I already have of the corn and other dry ingredients. Or I leave out some of the corn for the reason that the addition

of this may be convenient later on should the ratio happen to turn out too narrow at first. As a foundation for the mash, Middlings (Pollards) forms a cheap and useful foundation. This will therefore generally figure as the first item. Greenstuff should always be given in as large quantities as the fowls will consume, for some of the green foods such as grass and the clovers are of the cheapest foods we have. That, too, in addition to their being that foodstuff upon which we have to rely almost entirely for the supply of salts.

I will now give an example of a menu for the laying hen, and will also show how it is best to go about the making up of the same.

Note down, for instance, 4 Pollards, 4 Fish Refuse, 4 Maize meal, 1 Lentil flour, 2 Blood, 5 Grass, 5 Lucerne, as shown on the specimen "make up" I am giving herewith. The "3" in brackets is the proportion of fat due to the Grass and Lucerne. (See the footnote to Table IIIa). Now attach the values for Protein, Fat, &c., and add up.

	Protein.	Fat.	Carbo-hydrates.	Sodium.	Lime.	Cost.
4 Pollards	44	12	204 ..	44	184	540
4 Fish Refuse ..	44	8	0 ..	516	100	200
4 Maize Meal	28	16	268 ..	28	56	520
1 Lentil Flour ..	22	2	49 ..	147	70	265
2 Blood	34	0	0 ..	214	6	100
5 Grass	10	0	40 ..	130	290	50
5 Lucerne	10	(3)	30 ..	55	1300	50
$31\frac{1}{2} + 16 = 47\frac{1}{2}$	192	41	591 ..	1134	2006	
	10	2	31 ..	24	42	
1 Green-bone ..	20	3	0 ..	3	2840	160
2 Hempseed	24	50	44 ..	36	804	620
4 Maize	24	12	240 ..	28	56	480
4 Mangel-tops ..	4	(2)	16 ..	848	268	40
$47\frac{1}{2} + 23\frac{1}{2} + 5 = 76$	264	108	891 ..	2049	5974	
	10	4	34 ..	27	79	

1 Maize	6	3	60 ..	7	14	120
$76+3\frac{1}{2}=79\frac{1}{2}$ ..	270	111	951 ..	2056	5988	
	10	4	35 ..	26	75	
1 Lucerne	2	0	6 ..	11	260	10
1 Grass	2	0	8 ..	26	58	10
$79\frac{1}{2}+2=81\frac{1}{2}$	274	111	965 ..	2093	6306	3165
	10	4	35 ..	26	77	

The result of the addition is 192, 41, 591, together with 1134 and 2006 for the salts. The ratio figure for Protein is to be 10, for what we are aiming at for the organic substance is 10 : 4 : 35. We must therefore divide 192, also 38 and 591, by 19 (or to be exact 19.2), and we have: 10 : 2 : 31. We are thus both short of Fat and Carbohydrates. But before making further additions to put this right we will see how the salts stand. What we here want is 25 and 75 ozs. per ton of food. The total figures show 1134 and 2006 ozs. We shall therefore have to divide by the total number of tons of FOOD. The tons of foodstuff are 25; but these are not food in our sense, for, as FOOD we must designate that mixture which is made up of 25 parts of solids to 75 parts of water (1 to 3). As each ton of dry foodstuff such as Pollards, Lentil flour and Maize meal will make up, to roughly, $3\frac{1}{2}$ tons of FOOD, it is evident that $3\frac{1}{2}$ ozs. of salts in the original foodstuffs having to be spread over the $3\frac{1}{2}$ tons of ultimate food, only represent 1 oz. of salts per ton of that food. Before dividing our total ounces by the tons we shall therefore first need to multiply all the dry foodstuffs by $3\frac{1}{2}$. Thus 9 times $3\frac{1}{2}$ is $31\frac{1}{2}$. With the figures giving the tons of greenstuff, also the tons of "soft foods," such as Fish refuse, Blood, etc., we shall not need to interfere, for the proportion of water in these is practically normal. We must therefore divide the total ounces by $31\frac{1}{2}$ plus 16 or

47½, giving 24 and 42. Sodium is thus practically right but we are considerably short of Lime; Green bone will therefore have to come to the rescue. We are also very short of Fat; 2 of Hemp seed may thus be tried. Of the cereals, Maize is also one of the best for Fat, and as we have to increase the figure 31, for the Carbohydrates, to 35 and it will have been decreased by the addition of Green bone and Hemp seed, a fair amount of Maize will be necessary. Try 4. Through the addition of Green bone, Hemp seed and Maize we shall have lost ground considerably as regards Sodium, and as we are also short of greenstuff we will add 4 of Mangel tops and again add up. It now all adds up to: 264, 108, 891, 2049 and 5974. Divide the organic by 26 (26.4) and the salts by 76 (our tons of FOOD) and we have: 10 : 4 : 34; 27 and 79. We are thus not far wrong, but to increase the Carbohydrates we will add one more Maize. The figures now work out at: 10 : 4 : 35; 26 and 75. On looking up the total tons of dry food and green foods—soft foods do not count either way—we find we are rather short of the green, therefore to put this right and at the same time to cheapen the food we will add another Lucerne and another Grass, and the final figures are: 10 : 4 : 35; 26 and 77. That is quite near enough to what we require, so will do.

The total rations thus are:

4	parts of	Pollards.
4	,,	Fish Refuse.
4	,,	Maize Meal,
1	,,	Lentil Flour.
1	,,	Green Bone.
6	,,	Grass.
6	,,	Lucerne.
4	,,	Mangel Tops.
5	,,	Maize.
2	,,	Hemp Seed.

The Maize will, of course, be used in the form of Cracked-maize together with the Hemp Seed as scratching food. And if more scratching food is required some of the Maize-Meal may be replaced by Cracked-maize.

The cost will also be of interest. To obtain this per bird, per week, we must note down what each item costs. This I have done in an extra column. In all it is 3165 shillings according to the figures given on Table II. This must be divided by the total number of FOOD-TONS—not foodstuff tons—that is, by 81½ and not 39, and we get the cost of one ton of FOOD as being just 39 shillings. Each hen will require 100 ozs. of FOOD per week, and this we find to work out at just under 1⅓ of a penny. That, in itself, is a low figure as compared with many of the rations usually employed; and if it is remembered that most of those are quite inadequate as regards their composition and go to waste through being unbalanced, the difference between the two becomes apparent. If we have a large flock to feed it may be well worth our while to plod through a lengthy calculation, adding on cheap foods whenever possible, and thereby reducing the food bill. It may at first possibly be somewhat trying to those not accustomed to much arithmetical work, but by plodding on a useful result will be obtained. But our calculation will have another advantage, namely, this, that we shall gain a very intimate knowledge of the respective values of the various foodstuffs and an estimation of the importance of giving hens as much greenstuff as they may care to eat. If we are in the position to produce such greenstuff ourselves we shall also become conscious of the fact that fowls are not dependent on bought foods nearly as much as we may formerly have supposed. And this fact of being able to produce some of the food oneself is a very pleasing one. But, as to the price. The example above given works out at, as nearly as possible, 1⅓ of a penny. That is about the figure at which they usually work out. Some

cost a trifle more, some a trifle less. The price depends principally on the amount of green food given, for it will be seen that, whereas the cereals average about 200 feeding units per pound sterling, the green foods such as Grass and the Clovers average more than double that amount; the leaves of the root-plants come next, and the roots themselves are about on a level with the cereals. In a minor measure it depends on the kind of foodstuff, such as Fish meal, Granulated meat or Blood, employed as the chief ingredient of the mash. This, not for the reason of its particular price; that is of minor importance for, first of all, there is not much difference between the cost of the whole of the Protein foodstuffs—they are all rather high in price—and secondly, they possibly only represent one part out of twenty to thirty parts of the whole food, but more owing to its particular composition as regards the salts. It will be found that those rich in salts, such as Fish meal, Blood and Fish refuse, also Lentil flour, are apt to work out rather more favourably owing to the fact that they leave one freer to choose cheap foodstuffs instead of necessitating the employment of more unprofitable ones in ones endeavour to bring about the proper balance of salts.

In practice it will be found that the scope of foodstuffs available is narrowed down to not very many different sorts. As we are able to make up a very perfect combination it is, first of all, not necessary to change the diet much, we shall thus be justified in employing the more economical foodstuffs time after time, but, apart from this, we shall find that, as regards the green foods, we shall always be inclined to select from a few particular exponents showing high figures for Sodium and Lime. One will always be inclined to employ such plant-foods as Spinach, Lucerne, Swede-tops, Savoy cabbage, and the like, and find it very difficult to make use of others, should one have a wish to do so. Even grass, of all the green foods the

most balanced as regards the salts—also the cheapest—it is not easy to employ, the very fact of it being so well-balanced making it difficult to employ it in conjunction with the substances that are so one-sided. To bring about a cheap combination it is therefore important to arrive at a proper balance as rapidly as possible by seeing that the chief foodstuffs employed are well supplied with mineral matters, and then making up the full complement of the food by the addition of grass or other cheap foodstuffs according to the season of the year. If much grass is to be added in this way an excess of fat should be allowed in the first place as grass, as most other green foods, being poor in fat, would widen the proportion unnecessarily in this respect. A practical conclusion is oftentimes more valuable than long calculations, and the practical conclusion that may be drawn from what I have said is that it is wise to make a point of cultivating the more prominent exponents in the green-food department as much as possible. Spinach, Savoy, Cattle cabbage, Mangel tops,, Kohl rabi tops, Swede tops, Carrots and their tops, the Clovers, &c., &c., should all be cultivated. In mid-winter we shall, of course, be hard pressed, for none of these, excepting the Cabbage, will then be available. The different kinds of hay, excepting stinging-nettle hay and of which I will again speak lower down, are costly and are in my opinion not really suitable as food for fowls owing to the quantity of indigestible fibre they contain, we shall therefore have to fall back upon the roots—Mangel, Swedes, Carrots, &c.—and produce greenstuff by sprouting Oats, Barley, Mustard and the like. Mustard, the seed, by the way, should also be used as scratching food; Rape seed and Hemp seed being replaced by it in a moderate measure. It is, in fact, the best plan to mix a certain amount of this seed with the Rape seed and then not trouble more about the matter.

Of the cereals Maize easily holds first place. It is,

of course, hopelessly deficient in salts—2 ozs. of Sodium and 4 of Lime to the ton of food—but in this respect it is not worse than its fellows; on the other hand it is rich in fat as compared with these, and, above all things it is very low in cost.

A substance to which I wish to draw particular attention is Stinging-nettle hay. I have referred to this before, but it is worthy of further mention. The salts it contains are really marvellous as regards their high uniformity. The figures we find in Table III, where it appears at the bottom of the list—last, not least, it would appear—are a revelation. But not only that. If we take note of its organic components Table IIIa—for on Table III the figures are too large and confusing—we shall experience another surprise, for the figures read 10 : 4 : 29. Practice shows Stinging-nettle hay to be an excellent egg-producer; need we wonder? We, as Poultry keepers shall therefore be well advised to pay more attention to this unfriendly herb.

I do not know that I have much more to say now. I am subjoining a number of balanced rations. I have arranged them according to the standard on which they are based. Those having the organic ratio 10 : 4 : 35 I have taken first, these possibly being the most important, those having the ratios of 10 : 4 : 30 and 10 : 4 : 40 I have allowed to follow on. But in giving these ratios I realise that their scope is not nearly as large as might be desired by some who may refer to them for information. One difficulty I have no doubt many will experience is that they are so very poorly supplied with what is recommended in the way of green stuff. This, however, can, unfortunately, not well be altered before another summer has passed, but I would strongly recommend those who may have read this to make a study of the question with a view to producing and laying in a good stock of what is wanted for another winter.

To some it may appear that the variety of green stuff given in the rations is somewhat large. When

the question is more fully understood it will be realised that, although doubltessly the numbers of different green stuffs employed might be reduced somewhat, it is equally impossible to feed with one green stuff only, such as Spinach, as it is to feed with all Maize; and just as different cereals, etc., are needed to make up a balanced ration as regards the organic substances, so are different kinds of green stuff necessary to make up the complement of salts. There is, of course, no need to be over particular about the exact quantities; the best and simplest method, however, by which the desired object may be attained is to plan the mode of feeding ahead, arranging to grow the different kinds of plants in about the proportion required and then to give what there is, employing one's knowledge of the foodstuffs and one's sense of balance, as one goes along. This is the simplest method and one by which, in the long run, no great mistake can be made.

In conclusion I may say that I have thoroughly enjoyed working out and writing this little book, and if, as I hope, the reader may have enjoyed the reading as I the writing, we shall both have passed our time pleasantly, and too, I hope, profitably.

ARTHUR BOSSERT,

Caldecote, Cambridge.

RATIONS, having a ratio of:

10 : 4 : 35 —		25 : 75
1 Granulated meat	1	part by weight.
Pollards	3	,, ,,
Lentil flour	3	,, ,,
Barley meal	2	,, ,,
Cracked maize	6	,, ,,
Hemp seed	2	,, ,,
Swedes	2	,, ,,
Kohlrabi	2	,, ,,
Carrot tops	7	,, ,,
Swede tops	9	,, ,,
Mangel tops	3	,, ,,
2* Fish meal	1	part by weight.
Pollards	3	,, ,,
Bran	1	,, ,,
Maize meal	2	,, ,,
Dari	1	,, ,,
Rape seed	½	,, ,,
Swedes	2	,, ,,
Carrots	2	,, ,,
Cattle cabbage	2	,, ,,
Kohlrabi tops	4	,, ,,
Mangel tops	1	,, ,,
3* Blood (fresh)	1	part by weight.
Barley meal	4	,, ,,
Green bone	½	,, ,,
Rye	2	,, ,,
Rape seed	¾	,, ,,
Spinach	2	,, ,,
Cos lettuce	2	,, ,,
Swede tops	3	,, ,,
Leek tops	2	,, ,,

* The meals of this ration are: whole grain, ground.

RATIONS, having a ratio of:

10 : 4 : 35 — 25 : 75

4	Meat refuse	1	part by weight.
	Pollards	12	,, ,,
	Green bone	½	,, ,,
	Rape seed	1	,, ,,
	Lucerne	4	,, ,,
	Spinach	6	,, ,,
	Clover (red, in bloom)	4	,, ,,
	Carrot tops	2	,, ,,

5*	Fish refuse	6	parts by weight
	Pollards	5	,, ,,
	Barley meal	6	,, ,,
	Stinging nettle hay	2	,, ,,
	Green bone	¼	,, ,,
	Oats	4	,, ,,
	Rapeseed	1½	,, ,,
	Grass (average)	10	,, ,,
	Clover (red, in bloom)	10	,, ,,
	Spinach	3	,, ,,

6	Blood (fresh)	2	parts by weight
	Pollards	2	,, ,,
	Green bone	½	,, ,,
	Cracked maize	4	,, ,,
	Hemp seed	1	,, ,,
	Grass (average)	4	,, ,,
	Clover (white)	2	,, ,,
	Spinach	2	,, ,,

* The meals of this ration are: whole grain, ground.

RATIONS, having a ratio of :

10 : 4 : 35 — 25 : 75

7	Fish meal	1½	parts by weight
	Pollards	3	,, ,,
	Wheat (large)	6	,, ,,
	Cracked maize	1½	,, ,,
	Hemp seed	2	,, ,,
	Mangels	2	,, ,,
	Carrots	2	,, ,,
	Cattle cabbage	5	,, ,,
	Savoy	3	,, ,,

8*	Bean meal	2	parts by weight.
	Barley meal	4	,, ,,
	Stinging nettle hay.....	1	,, ,,
	Hemp seed	1¼	,, ,,
	Mangel tops	3	,, ,,
	Swede	1	,, ,,

* The meals of this ration are : whole grain, ground.

RATIONS, having a ratio of :

10 : 4 : 30 — 25 : 75

9	Fish meal	1	part by	weight.
	Pollards	3	,,	,,
	Lentil flour	1	,,	,,
	Cracked maize	3	,,	,,
	Hemp seed	1¼	,,	,,
	Grass (best pasture)	4	,,	,,
	Trifolium	4	,,	,,
	Cos lettuce	2	,,	,,
10	Blood (fresh)	1	part by	weight.
	Pollards	6	,,	,,
	Green bone	½	,,	,,
	Hemp seed	1	,,	,,
	Grass (young)	3	,,	,,
	Cattle cabbage	2	,,	,,
	Spinach	2	,,	,,
11*	Granulated meat	1	part by	weight.
	Dried blood	1	,,	,,
	Pollards	8	,,	,,
	Maize meal	4	,,	,,
	Green bone	½	,,	,,
	Wheat (large)	4	,,	,,
	Hemp seed	3½	,,	,,
	Clover (red, in bloom)	8	,,	,,
	Mustard plant (white)	5	,,	,,
	Savoy	10	,,	,,
	Spinach	4	,,	,,

* The meals of this ration are: whole grain, ground.

RATIONS, having a ratio of :

10 : 4 : 30 — 25 : 75

12*	Fish meal	1½	parts by weight
	Pollards	3	,, ,,
	Bran	1	,, ,,
	Maize meal	1	,, ,,
	Wheat (small)	1	,, ,,
	Dari	2	,, ,,
	Rape seed	½	,, ,,
	Swedes	2	,, ,,
	Carrots	2	,, ,,
	Cattle cabbage	2	,, ,,
	Mangel tops	1	,, ,,

13	Meat refuse	1	part by weight.
	Pollards	4	,, ,,
	Hemp seed	½	,, ,,
	Lucerne	3	,, ,,
	Cattle cabbage	2	,, ,,
	Savoy cabbage	2	,, ,,
	Spinach	1½	,, ,,

14*	Bean meal	2	parts by weight.
	Barley meal	2	,, ,,
	Hemp seed	1	,, ,,
	Lucerne	3	,, ,,
	Clover (white)	2	,, ,,
	Spinach	2	,, ,,

* The meals of this ration are: whole grain, ground.

RATIONS, having a ratio of:

10 : 4 : 30 — 25 : 75

15*	Fish refuse	3	parts by weight.	
	Pollards	4	,,	,,
	Brewers' grains (dried)	2	,,	,,
	Maize meal	1	,,	,,
	Rapeseed	½	,,	,,
	Grass (best pasture)	2	,,	,,
	Lucerne	3	,,	,,
	Spinach	2	,,	,,
	Swede tops	4	,,	,,

* The meals of this ration are: whole grain, ground.

RATIONS, having a ratio of:

10 : 4 : 40 — 25 : 75

16*	Granulated meat	1	part by weight.
	Pollards	6	,, ,,
	Maize meal	1	,, ,,
	Green bone	1	,, ,,
	Cracked maize	5	,, ,,
	Rye	3	,, ,,
	Rape seed	1	,, ,,
	Carrots	3	,, ,,
	Jerusalem Artichokes ...	2	,, ,,
	Savoy	5	,, ,,
	Mangel tops	5	,, ,,
	Swede tops	6	,, ,,

17	Blood (fresh)	3	parts by weight.
	Pollards	6	,, ,,
	Bran	3	,, ,,
	Cracked maize	$5\frac{1}{2}$	,, ,,
	Stinging nettle hay	$2\frac{1}{2}$	,, ,,
	Hemp seed	$1\frac{1}{2}$	,, ,,
	Mangels	3	,, ,,
	Kolrabi	5	,, ,,
	Jerusalem Artichokes ...	2	,, ,,
	Cattle cabbage	2	,, ,,
	Savoy	2	,, ,,

---

* The meals of this ration are: whole grain, ground.

RATIONS, having a ratio of :

10 : 4 : 40 — 25 : 75

18	Fish meal	1	part by	weight.
	Pollards	2	,,	,,
	Cracked maize	3	,,	,,
	Rye	3	,,	,,
	Rape seed	¾	,,	,,
	Mangels	2	,,	,,
	Carrots	2	,,	,,
	Mangel tops	3	,,	,,
	Carrot tops	3	,,	,,
	Sprouted barley	2	,,	,,
19	Pollards	2	,,	,,
	Linseed cake meal	2	,,	,,
	Stinging nettle hay	2½	,,	,,
	Cracked maize	3	,,	,,
	Buckwheat	5½	,,	,,
	Rape seed	½	,,	,,
	Mangel tops	4	,,	,,
	Swede tops	3	,,	,,
	Cattle cabbage	2	,,	,,
	Sprouted oats	8	,,	,,
	Pollards	4	,,	,,
20*	Meat refuse	1	part by	weight.
	Pollards	6	,,	,,
	Maize meal	2	,,	,,
	Green bone	½	,,	,,
	Hemp seed	½	,,	,,
	Mangel tops	4	,,	,,
	Swede tops	4	,,	,,

* The meals of this ration are: whole grain, ground.

RATIONS, having a ratio of:

10 : 4 : 40 — 25 : 75

21*	Fish refuse	3	parts by weight.
	Barley meal	7½	,, ,,
	Stinging nettle hay	1	,, ,,
	Hemp seed	1½	,, ,,
	Mangel tops	3	,, ,,
	Swede tops	8	,, ,,
	Kohlrabi tops	4	,, ,,
22*	Bean meal	2	part by weight.
	Barley meal	6	,, ,,
	Stinging nettle hay	1	,, ,,
	Hemp seed	1¼	,, ,,
	Mangel tops	3	,, ,,
	Swede tops	4	,, ,,
23	Blood (fresh)	1	part by weight.
	Pollards	6	,, ,,
	Stinging nettle hay	1½	,, ,,
	Cracked maize	1½	,, ,,
	Rape	½	,, ,,
	Mangel tops	3	,, ,,
	Swede tops	2	,, ,,

* The meals of this ration are: whole grain, ground.

24	Wheat (large)	1	part by weight.
	Grass (average)	1	,, ,,

gives a ratio of

10 : 1 : 6 — 9 : 23

from which it will be seen that the salts are deplorably deficient in spite of as much grass having been allowed as wheat.

It will also be noticed that the ratio of the organic substances is quite faulty. What the results of such feeding must be, may be imagined.

ARTHUR BOSSERT,

Caldecote, Cambridge.

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